

**REMEDIAL DESIGN/REMEDIAL ACTION  
(RD/RA) WORK PLAN  
TASK 1**

**G&H Landfill Site  
Macomb County, Michigan**

**OCTOBER 1993**

**REF. NO. 5132 (6)**

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**CONESTOGA-ROVERS & ASSOCIATES**

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APL	Aqueous Phase Liquids
BGS	Below Ground Surface
CD	Consent Decree
CRA	Conestoga-Rovers & Associates (Project Consultant, Engineer)
DWSD	Detroit Water and Sewer District
EWDP	Extraction Well Design Program
FML	Flexible Membrane Liner
FS	Feasibility Study
GMP	Groundwater Monitoring Program
Group	G & H Landfill Site PRP Group
LFG	Landfill Gas
MDNR	Michigan Department of Natural Resources
NAPL	Non Aqueous Phase Liquids
NPL	National Priorities List
PRP	Potentially Responsible Parties
RA	Remedial Action
RD	Remedial Design
RD Work Plan	Remedial Design Work Plan
RI	Remedial Investigation
ROD	Record of Decision
Site	G & H Landfill Site
SOW	Scope of Work
SSPL	Site-Specific Parameter List
SSPS	Soil/Sediment PCB Sampling
SWDP	Slurry Wall Design Program
SWSMP	Surficial Water and Sediment Monitoring Program
U.S. EPA	United States Environmental Protection Agency

## 1.0 INTRODUCTION

The purpose of this document is to present the Remedial Design/Remedial Action Work Plan (RD/RA Work Plan) for the G & H Landfill Site (Site) located in Macomb County, Michigan. This RD/RA Work Plan has been prepared to satisfy the requirements of Task 1 of the Scope of Work (SOW) developed for the Remedial Design/Remedial Action (RD/RA) for the G & H Landfill Site. This section provides an overview of the Site RD/RA project.

### 1.1 GENERAL OVERVIEW

This document presents the RD/RA Work Plan for the G & H Landfill Site (Site) which addresses the design and implementation of the following Site-wide remedy components:

1. Landfill Cap;
2. Source Containment System;
3. Groundwater Extraction/Treatment System; and
4. Fence Installation.

Additionally, this RD/RA Work Plan presents the design and scope of the following investigative programs and pre-design evaluations which are necessary to support the design and implementation of the Site-wide remedy:

1. Site Access Agreement;
2. Boundary and Topographic Survey;
3. Landfill Capping Materials Evaluation;
4. Landfill Gas Evaluation;
5. Wetlands Evaluation/Mitigation Program;
6. Source Contaminant System Evaluation;
7. Slurry Wall Design Program;
8. Groundwater Monitoring Program;
9. Extraction Well Design Program;

10. Groundwater Treatability Studies;
11. Evaluation of Discharge Requirements;
12. Soil/Sediment PCB Sampling Program;
13. Surficial Water and Sediment Monitoring Program;
14. Automobile Disposal Yard Data Evaluation; and
15. Municipal Water Connection Program;

The G & H Landfill Site is located in the northeast quarter of Section 19, Shelby Township, Macomb County, Michigan. It is approximately 23 miles north of Detroit. The Site operated as a waste oil reclamation facility from 1955 to 1967 and a landfill from approximately 1955 to 1973. The landfill was closed to disposal activities in 1974. The Site location is presented on Figure 1.1. A Site plan is presented on Figure 1.2. An aerial photograph of the Site depicting Site conditions on November 21, 1983 is presented as Plan 1.

A Remedial Investigation/Feasibility Study (RI/FS) was completed by U.S. EPA during the period from 1983 to 1990. The RI/FS culminated in the issuance of a Record of Decision (ROD) in December 1990. Detailed background information for the Site is provided in the respective documents identified above (i.e. RI, FS, ROD). Background information is summarized in Section 1.2.

This RD/RA Work Plan has been developed pursuant to the requirements of the Consent Decree (CD) in the matter of United States of America (USA) vs. Browning-Ferris Industries et al. A Scope of Work (SOW) for the RD/RA at the Site is incorporated into the CD by reference. The SOW outlines the conceptual approach to design and implement the individual remedy components of the Site-wide remedy. The tasks required to implement the SOW are summarized and presented in Table 1.1. The RD/RA Work Plan has been developed pursuant to the requirements of Task 1 of the SOW.

The major components of the remedy for the Site, as outlined in the SOW, include investigative, design or construction activities associated with the following:

- A) Landfill Cap;
- B) Source Containment System;
- C) Junkyard (i.e. Automobile Disposal Yard);
- D) PCB in Soils/Sediments;
- E) Installation and Operation of a Groundwater Extraction, Collection, Treatment and Discharge System;
- F) Fence Installation;
- G) Groundwater, Surface Water and Sediment Monitoring Program;
- H) Air Monitoring;
- J) Disposal of Groundwater Treatment Sludges;
- K) Wetlands;
- L) Municipal Water Supply;
- M) Technology Review; and
- N) Institutional Controls.

Components of the Site remedy are discussed in the following paragraphs.

A landfill cap meeting Michigan Act 64 standards will be constructed over the limits of the Phase I, II and III landfills. The expected limit of the areas to be capped is presented on Figure 1.3. The landfill cap will be comprised of the following components (or equivalent):

- "1. A vegetative topsoil layer which is a minimum 6 inches thick that will sustain plant growth (e.g., prairie grass) and will control erosion and promote drainage;*
- 2. A common fill soil layer which is a minimum two feet thick, unless U.S. EPA, in consultation with MDNR, determines that a lesser amount of common fill soil would maintain the hydraulic conductivity of the entire clay layer at  $1 \times 10^{-7}$  centimeters per second (cm/s) in which case a minimum of one foot of common fill soil may be utilized;*

3. *A sand/gravel drainage layer which is a minimum one foot thick that will minimize precipitation infiltration into the low permeability layer. The sand/gravel drainage layer shall have a minimum hydraulic conductivity of  $1 \times 10^{-3}$  cm/s:*
4. *A low permeability, compacted clay layer that minimizes precipitation infiltration into the landfill. The clay layer shall be a minimum of three feet and have a maximum hydraulic conductivity of  $1 \times 10^{-7}$  cm/s; and*
5. *a gas venting system capable of removing methane gas build-up beneath the cover, and installed in a manner which does not increase the hydraulic conductivity of the cap above  $1 \times 10^{-7}$  cm/s. Gas venting shall comply with the substantive requirements of an air quality permit under Michigan Act 348, as approved by U.S. EPA, in consultation with MDNR, "(SOW, page 23/24).*

In addition, the landfill caps over each of the three landfills must be designed to maintain a minimum slope of 2 percent. The preliminary subgrade plans for the landfill caps, as developed in the FS, are presented on Figure 1.4. The selection of the landfill cap system will be based upon an evaluation of various materials and options completed during the pre-design.

The source containment system will be constructed to hydraulically and physically isolate the Phase I, II and III landfill areas and the oil seep area. The source containment system consists of one of two alternatives. The first alternative consists of a groundwater collection trench along the southern limit of the Phase I and II landfills and oil seep area with a downgradient slurry wall or vertical flexible membrane liner (FML). The components of the first option for the source containment are presented on Figure 1.5. The second alternative consists of a network of groundwater extraction wells (i.e. source extraction wells) along the southern limit of the Phase I and II landfills and oil seep area with a downgradient slurry wall. The components of the second option for the source containment system are

presented on Figure 1.6. The selection of the source containment system will be based upon an evaluation of the alternatives completed during the pre-design.

Figure 1.7 presents the proposed groundwater extraction system which will be designed to capture, draw back and remove the groundwater contaminant plume located outside and downgradient of the source containment system.

Figure 1.8 presents the alignment of the Site security fence which will be designed and installed upon completion of the RA construction.

Figure 1.9 presents the wetland areas that may be affected as a result of the Site RA. A wetland replacement program will be developed to replace wetlands lost or adversely affected by the Site RA.

Figure 1.10 presents the location of residences and businesses along and to the east of Ryan Road which are to be connected to the municipal water supply.

The design process for each of these remedy components is discussed in this RD/RA Work Plan. In certain instances, the RD of the various remedy components will require that pre-design studies or evaluations be conducted to provide the necessary information to support the RD. In those instances, this RD/RA Work Plan presents the scope of the necessary pre-design studies which will be implemented to support the design. In general, pre-design studies and investigations will be conducted prior to the submittal of the 30 percent design.

This RD/RA Work Plan has been developed by Conestoga-Rovers & Associates (CRA), on behalf of the G & H Landfill Site PRP Group (Group). It should be noted that this RD/RA Work Plan presents a conceptualized approach to the pre-design studies, RD and RA for the Site. Modifications to this RD/RA Work Plan may be required from time to time to take into account new information or science which may come available.

In these instances modifications to the scope presented in the RD/RA Work Plan will be presented to U.S. EPA for review and approval.

## 1.2 SITE BACKGROUND

The G & H Landfill Site is located in the northeast quarter of Section 19, Shelby Township, Macomb County, Michigan. It is approximately 23 miles north of Detroit. The Site operated as a waste oil reclamation facility from 1955 to 1967 and a landfill from approximately 1955 to 1973. The landfill was closed to disposal activities in 1974. The Site location is presented on Figure 1.1. A Site plan is presented on Figure 1.2

Since the mid-1950s, the area in the vicinity of the Site has changed from a rural setting to a residential area. Most of the land in the vicinity was used for farming or sand and gravel mining. Presently, there is a residential area east of Ryan Road and a new housing development north of 23 Mile Road. The Rochester-Utica State Recreational Area lies just south of the landfill areas. Shelby Township manages the bulk of the recreation area. MDNR manages portions of the recreation area that have been determined to be affected by releases from the Site. A portion of the Rochester-Utica State Recreational Area is included in the definition of the Site.

The Site boundaries are currently defined by the Site fence as shown on Figure 1.2. Approximately 60 acres of the Site lie between an abandoned Conrail Railroad right-of-way and 23 Mile Road. This area is bordered on the east by two commercial facilities: a portable sanitation manufacturer and a petroleum products distributor. An inactive automobile salvage yard (i.e. junkyard), located directly north of the commercial area, is included in the definition of the Site. Although this area was not used for municipal refuse disposal, it may have been used for the disposal of other waste materials. The junkyard is littered with the remains of automobiles, trucks and construction equipment. Another 40 acres of the Site is located to the southwest of the railroad grade. This area is bounded on the south by wetlands and woodlands and on the west by the Clinton River. A small pond fed by surface runoff exists north of the Phase III Landfill.

The Detroit Water and Sewer District (DWSD) has a north-south pipeline easement in the western portion of the Site. The easement is for a 96-inch diameter waterline and a 24-inch near-surface interceptor sanitary sewer. The waterline, constructed in 1967, serves as the main water distribution line from Lake Huron to Detroit. The interceptor, which serves Shelby Township, is connected to a 96-inch diameter regional interceptor beneath the Site. The regional interceptor serves Oakland County and connects to the Sewer District's main treatment plant. This large interceptor was constructed in 1971 and is approximately 40 feet below ground surface (BGS).

Various abandoned facilities intersect the Site. An abandoned railroad right-of-way, formerly part of the Conrail system, runs through the Site in a northwest to southeast direction. A spur line right-of-way runs northward on the western edge of the Site. The Clinton-Kalamazoo Canal, an abandoned navigation project, runs east to west through the woodlands south of the Site and turns northward along the western edge of the Site. The canal is a 20-foot wide ditch filled with debris in the Phase III Landfill. The ditch carries water intermittently. The woodland area to the south contains many abandoned sand and gravel mining trenches.

The Site contains three distinct landfilled areas (Figure 1.2):

- Phase I Landfill        44 acres
- Phase II Landfill       17 acres
- Phase III Landfill      8 acres

Differential settling of the landfills has resulted in uneven terrain with numerous depressions on the landfill surfaces. The landfill surfaces are at approximately the same elevation as 23 Mile Road. The Phase I and II Landfills are covered with grasses, weeds, scrub brush and small trees. The Phase III Landfill has relatively little vegetation. The Phase II Landfill has a steep southern slope that terminates in woodlands to the south. The

Phase III Landfill has a steep slope to the west and south. Leachate seeps have been identified along the western side of the Phase III Landfill.

### 1.3 RD/RA WORK PLAN PURPOSE AND ORGANIZATION

#### 1.3.1 Purpose

Task 1 of the SOW requires that the Group prepare a RD/RA Work Plan. Task 1A of the SOW outlines the requirements for the RD *"which describes the overall management strategy for the design phase of the remedial action. Plans and schedules for groundwater treatability testing, slurry wall compatibility testing, plans and schedule for PCB soil/sediment investigation, and remedy implementation shall be included in the RD Work Plan. The draft RD Work Plan is due 60 days after lodging of the Consent Decree. The final RD Work Plan is due 45 days after Settling Defendants receive EPA comments on the draft RD Work Plan. The RD Work Plan shall also include a description of the responsibility, authority and qualifications of key personnel directing the RD, including contractor personnel"* (SOW, page 23). The final RD Work Plan was submitted to U.S. EPA on April 19, 1993 and was approved on April 22, 1993.

The RD/RA Work Plan presented herein was developed from the approved RD Work Plan(updated to include the RA requirements).

Task 1B of the SOW outlines the requirements for the RD/RA Work Plan. The RA portion is to describe *"the overall management strategy for performing the construction, operation and maintenance, and monitoring of the remedial action. To the extent known, the RD/RA Work Plan shall also describe the responsibility, authority, and qualifications of all organizations and key personnel involved with the implementation of the Work required under the Consent Decree and this SOW."* (SOW, page 23).

More specifically, the RD/RA Work Plan addresses the following subjects, as required by the SOW:

- A. Description and Qualification of Personnel;
- B. Slurry Wall Compatibility Evaluation;
- C. Soil/Sediment PCB Sampling Program;
- D. Groundwater Treatability Study;
- E. Health and Safety Plan (HASP);
- F. Quality Assurance Project Plan (QAPP);
- G. Monitoring/Sampling Plan (SAP); and
- H. Project Schedule.

### 1.3.2 Organization

This RD/RA Work Plan is organized as the following sections:

Section 2	Description and Qualifications of Personnel
Section 3	RD Project Plans
Section 4	Pre-Design Activities
Section 5	Remedial Design Activities
Section 6	Remedial Action Activities
Section 7	Reports and Documentation
Section 8	Community Relations
Section 9	Schedule
Section 10	References

Additionally, this RD/RA Work Plan includes the following appendices:

Appendix A	Sampling and Analysis Plan (SAP)
Appendix B	Quality Assurance Project Plan (QAPP)
Appendix C	Health and Safety Plan (HASP)
Appendix D	Curricula Vitae of Project Team
Appendix E	Groundwater Modeling Information

#### 1.4 BASIS FOR RD/RA

The RD/RA for the Site will be based on the provisions of the Consent Decree (CD) and the Scope of Work (SOW) attached thereto, U.S. EPA Superfund Remedial Design and Remedial Action Guidance, and other appropriate guidances that may be provided by U.S. EPA.

## 2.0 DESCRIPTION AND QUALIFICATIONS OF PERSONNEL

The project management organization for the G & H Landfill Site RD/RA is schematically presented on Figure 2.1. The responsibilities of each of the following project team members are briefly summarized in the following subsections:

2.1 G & H Landfill Site PRP Group (Group)

2.2 Conestoga-Rovers & Associates (Engineer)

### 2.1 G & H LANDFILL SITE PRP GROUP (GROUP)

The G & H Landfill Site PRP Group (Group) will coordinate the overall management of all technical and legal activities relating to the implementation of the RD/RA.

### 2.2 CONESTOGA-ROVERS & ASSOCIATES (ENGINEER)

Conestoga-Rovers & Associates (CRA or Engineer) will provide overall technical project management and field oversight services during the implementation of the RD Program. The Engineer will provide technical support and will oversee all investigative and design activities associated with this project.

The Engineer will provide a qualified field engineer and additional field support personnel as required to oversee the required activities. The field engineer will report directly to the Project Coordinators and will oversee on-Site activities on a daily basis. The field engineer will function as the Project Coordinator's on-Site representative for day-to-day Site activities. The project organization is schematically presented on Figure 2.1. Curricula Vitae for the various RD project team members are provided in Appendix D.

The responsibilities of each of the following project team members are discussed in the following subsections:

- 2.2.1 Project Manager
- 2.2.2 Project Coordinators
- 2.2.3 Remedial Design Project Coordinator(s)
- 2.2.4 Contract Administrator/Specialist
- 2.2.5 Design Engineer(s)
- 2.2.6 Quality Assurance Officer (QAO)
- 2.2.7 Health and Safety Officer (HSO)
- 2.2.8 Project Consultant Subcontractors

2.2.1 Project Manager - Mr. Alan Van Norman, P. Eng.

The Project Manager will oversee all aspects of the project and will be actively involved in the direction of the project. The Project Manager will attend technical meetings (as required) and ensure that high standards of technical merit, scheduling and budget control are maintained throughout all project activities. The Project Manager will be briefed regularly during all activities by the other project team members.

2.2.2 Project Coordinators - Ian Richardson, P. Eng./  
Glenn Turchan, P. Eng.

The Project Coordinator's role is to direct the Project Team's efforts and focus them on the SOW with due regard for technical considerations and schedule. The Project Coordinator's will also participate in the definition of amendments to the SOW that may be appropriate and the resolution of problems that may develop as the project proceeds. In addition, the Project Coordinators will be Engineer's primary representative of the Project to the regulatory agencies. Additional duties include:

- overview of field activities,
- overview of laboratory activities,

- coordination of design teams,
- data assessment, and
- managerial guidance to Group.

#### 2.2.3 Remedial Design Project Coordinators-Landfill Cap Cover Program/Source Containment Program/Groundwater Extraction/Treatment Program

The Remedial Design Project Coordinators will be responsible for all technical activities relating to the completion of the Landfill Cap, Source Containment and Groundwater Extraction/Treatment Programs. The Remedial Design Project Coordinators shall focus the efforts of all design engineers/staff with regard to scope and efficiency.

#### 2.2.4 Contract Administration/Specialist

The Contract Administrator will serve as the contract specialist for the G & H Landfill Site RD. The Contract Administrator will form an integral part of the overall Project Team.

#### 2.2.5 Project Design Engineers

The Project Design Engineers are responsible for the day-to-day coordination of the design, successful completion of all field activities, development of designs, development of plans and the preparation of draft reports. The Design Engineers report to the respective Remedial Design Project Coordinators. The Design Engineers will oversee all activities completed by the other required support staff.

#### 2.2.6 Quality Assurance Officer (QAO)

The Quality Assurance Officer (QAO) is responsible to ensure that all data quality objectives as identified in the QAPP are maintained. Additional activities include:

- systems audits - laboratory activities;
- overview and review field QA/QC;
- co-ordinate supply of performance evaluation samples;
- review laboratory QA/QC;
- data validation and assessment;
- advise on data corrective action procedures;
- preparation and review of reports; and
- QA/QC representation of project activities.

#### 2.2.7 Health and Safety Officer (HSO)

The Health and Safety Officer (HSO) is responsible to ensure that all health and safety requirements are effectively employed and enforced during activities completed on Site.

#### 2.2.8 Project Subcontractors

CRA has hired the following subcontractors to support the completion of the pre-design and design activities:

1. Licensed Land Surveyor (Darrell D. Hughes & Associates, Fowlerville, MI)
2. Drilling Contractor (Layne Northern, Lansing, MI)
3. Analytical Laboratory (ENCOTEC, Ann Arbor, MI)
4. Geotechnical Laboratory (Empire Soils, Middleport, NY)
5. Slurry Wall Consultant (Dr. Moir Haug, Saskatoon, Saskatchewan)
6. Treatment Vendor(s) (as required) (TreaTek-CRA), Niagara Falls, NY

The organization of the project subcontractors is schematically presented on Figure 2.2. Professional qualifications statements or resumes for the various subcontractors are also presented in Appendix D.

### 3.0 RD PROJECT PLANS

The section provides an overview of the following Project Plans which are presented as appendices to this RD/RA Work Plan:

Appendix A - Sampling and Analysis Plan (SAP)

Appendix B - Quality Assurance Project Plan (QAPP)

Appendix C - Health and Safety Plan (HASP)

The Project Plans are designed to provide the procedures and protocols which are necessary to support pre-design studies or evaluations.

#### 3.1 SAMPLING AND ANALYSIS

A Site-specific Sampling and Analysis Plan (SAP) is required to ensure that all pre-design and design activities requiring sampling and analyses are performed to established and accepted protocols. All sampling and analysis will be conducted as part of a quality assurance program to ensure that accurate and precise results are obtained. All sampling and analysis activities will be completed in accordance with the Sampling and Analysis Plan (SAP) presented as Appendix A

#### 3.2 QUALITY ASSURANCE PROJECT PLAN

The field and laboratory quality assurance objectives, protocols and procedures to support RD activities are provided in the Quality Assurance Project Plan (QAPP) presented as Appendix B.

#### 3.3 HEALTH AND SAFETY

A Site-specific Health and Safety Plan (HASP) is required to ensure that all pre-design and design activities are performed safely and in

accordance with applicable regulatory requirements, and that all persons on Site, the general public and the environment are protected from exposure to Site-related contaminated material. The health and safety requirements addressing all investigative design activities are provided in the Health and Safety Plan presented as Appendix C.

#### 4.0 PRE-DESIGN ACTIVITIES

In order to perform the RD for the Site, additional investigations, studies or evaluations are required to supplement the data presented in the Remedial Investigation (RI) Report (CH2M Hill, August 6, 1990). The pre-design activities required to provide the additional information are discussed in the following subsections:

- 4.1 Site Access Agreements
- 4.2 Boundary and Topographic Survey
- 4.3 Landfill Capping Materials Evaluation
- 4.4 Landfill Gas Evaluation
- 4.5 Wetlands Evaluation/Mitigation Program
- 4.6 Source Containment System Evaluation
- 4.7 Slurry Wall Design Program
- 4.8 Groundwater Monitoring Program
- 4.9 Extraction Well Design Program
- 4.10 Groundwater Treatability Studies
- 4.11 Evaluation of Discharge Requirements
- 4.12 Soil/Sediment PCB Sampling Program
- 4.13 Surficial Water/Sediment Monitoring Program
- 4.14 Automobile Disposal Yard Data Evaluation
- 4.15 Municipal Water Connection Program

All pre-design activities will be performed in accordance with the appropriate protocols and procedures presented in the SAP, QAPP and HASP, which are respectively presented in Appendices A, B and C. It should be noted that to the extent practicable the field activities will follow the procedures and protocols presented in this RD/RA Work Plan. It may, however, be necessary from time to time to modify the protocols and procedures to account for Site-specific field conditions. In these instances, modifications to the protocols and procedures may be made subject to prior consultation with U.S. EPA and/or its representatives, including MDNR.

#### 4.1 SITE ACCESS AGREEMENT

As of the date of lodging of the Consent Decree, access was provided at all times for the Group, Group's representatives, Group's Contractors and Subcontractor(s) and representatives of U.S. EPA to *"those portions of the Site owned by the Estate of Leonard Forster in accordance with the Consent for Access executed by the Estate of Leonard Forster and attached hereto as Appendix 7"* (Consent Decree, page 27). The portions of the Site that are owned by the Estate of Leonard Forster include the Phase I, II and III Landfills and Automobile Disposal Yard (Junkyard).

Access is also provided *"to any other property controlled by, or available to, Settling Defendants to which access is necessary to effectuate the remedial design or remedial action required pursuant this Decree"* (Consent Decree, page 27) which includes the MDNR managed portion of the Rochester-Utica Recreational Area (fenced portion).

For off-Site properties, the Group will use best efforts (in accordance with the Consent Decree) to obtain access from the owners of all property necessary to conduct the activities required by the SOW. Access to all necessary properties will be coordinated prior to initiation of activities. If obtained, the agreement is expected to permit access for the Group, Group's representatives, Group's Contractor and Subcontractor(s), and representatives of U.S. EPA for the purpose of performing all activities as presented herein. If, despite use of their best efforts, the Group cannot obtain access agreements, the Group shall notify U.S. EPA. In such a case, U.S. EPA shall use their best efforts to otherwise secure access to the required properties on behalf of the Group.

Access will be required for off-Site properties for both the pre-design investigations and for the construction of various remedial components. It is anticipated that the following pre-design investigations will require access to properties located adjacent to the Site:

1. Groundwater Monitoring Program;
2. Municipal Water Connections; and

### 3. Surveying.

Access for the above identified pre-design investigations are discussed in the following titled paragraphs.

#### Groundwater Monitoring Program

Access will be required to various properties to permit activities associated with the Groundwater Monitoring Program, including monitoring well installation, monitoring well abandonment and groundwater sampling (see Section 4.8). More specifically, access will be required to properties located along the north side of 23 Mile Road and the east side of Ryan Road. Access will be required from the Macomb County Road Commission, Permit Department for abandonment of the existing monitoring well couplets (GH14A,B; GH15A,B; GH16A,B).

Depending on the location of the monitoring well couplets, access may be required from either the Macomb County Road Commission or the individual property owners associated with the residential lots located along the north side of 23 Mile Road and along the east side of Ryan Road. Since the actual location of the new monitoring well couplets will be determined in the future (in consultation with the U.S. EPA), it is necessary that prior access be obtained from owners of all properties that are potential locations for the installations (if the exact locations for the monitoring wells are not precisely known).

#### Municipal Water Connections

As discussed in Section 4.15, approximately twenty-three (23) residences and six (6) businesses currently require connection to the local municipal water supply. The properties are located along Ryan Road and in the Kemler subdivision (southeast corner of Ryan Road and 23 Mile Road). The Group will contact the various property owners to determine which owners would request to be connected to the municipal supply. Access will then be required for both municipal water connection and abandonment of

the existing private wells. Section 4.15 addresses additional access and permitting requirements for municipal water supply connections.

### Surveying

Access will also be required (as necessary) to the properties associated with the installation of the monitoring well couplets for the purpose of surveying the new monitoring well installations. The access agreements for these properties will be designed to incorporate all associated activities including the surveying.

### Remedial Action Access Requirements

Access may be required to various properties located adjacent to the Site for the construction of the following remedial components:

1. landfill cap;
2. groundwater extraction system;
3. source containment system; and
4. fence installation following remedial action.

The properties that may be affected by the construction of these components include the commercial properties along the west side of Ryan Road (directly south of the Junkyard). During the pre-design activities efforts will be made to identify the owners of the properties that may potentially require access for remedial construction. Coordination to obtain access to the properties will be addressed and presented in the 30 percent design.

Access to the Detroit Water and Sewer Department (DWSD) easement will be required during the RA in relation to the landfill cap, slurry wall, source containment system (including upgradient DWSD extraction well(s)) and groundwater extraction system. A formal agreement will be arranged with the DWSD regarding construction and maintenance of the remedial components.

#### 4.2 BOUNDARY AND TOPOGRAPHIC SURVEY

A topographic base plan will be developed during the pre-design investigation to present conditions at the Site. The Site plan will be electronically developed utilizing aerial mapping techniques. The Site plan will be used during the pre-design activities to present investigative results and sampling locations. Subsequently, the electronic Site base plan will be utilized to support all on-Site design activities.

#### 4.3 LANDFILL CAPPING MATERIALS EVALUATION

The landfill capping materials evaluation is required to support the assessment and design of the landfill cover. The cover is specified in the SOW to include:

- *"A vegetative topsoil layer which is a minimum 6 inches thick that will sustain plant growth (e.g., prairie grass) and will reduce erosion and promote drainage;*
- *A common fill soil layer which is a minimum 2.0 feet thick, unless EPA, in consultation with MDNR, determines that a lesser amount of common fill soil would maintain the hydraulic conductivity of the entire clay layer at  $1 \times 10^{-7}$  centimeters per second ("cm/s") in which case a minimum of 1.0 foot of common fill soil may be utilized;*
- *A sand/gravel layer which is a minimum 1 foot thick that will minimize precipitation infiltration into the lower permeability layer. The sand/gravel drainage layer shall have a minimum hydraulic conductivity of  $1 \times 10^{-3}$  cm/s;*
- *A low permeability, compacted clay layer that minimizes precipitation infiltration into the landfill. The clay layer shall be a*

*minimum 3.0 feet thick and have a maximum hydraulic conductivity of  $1 \times 10^{-7}$  cm/s". (SOW, page 1-2).*

Over the past two years, considerable research has been published on the impact of frost penetration on soil covers (Johnson and Haug, 1992, and Benson, 1993). This research has shown that freeze-thaw cycles may significantly increase the hydraulic conductivity of soil liners and covers. The hydraulic conductivity of low permeability clay soils may generally increase, over time with freeze-thaw cycles, to approximately  $10^{-5}$  cm/s. Some minimization in the increase in hydraulic conductivity can be obtained by applying a surcharge (generally little or none in covers). However, only a single freeze-thaw cycle can increase the hydraulic conductivity of a cover material by up to one order of magnitude. To date, the only exception to this has been bentonite modified soil covers (eg. bentonite mats) which have been found to maintain hydraulic conductivities in the range of  $10^{-8}$  to  $10^{-9}$  cm/s after being subjected to freeze-thaw (Wong and Haug, 1991).

As a result, the landfill capping materials evaluation will also include an assessment of viable landfill capping options. This will include an assessment of the use of a flexible membrane liner (FML) or geosynthetic clay layer (GCL) (eg. bentonite mat) as an alternate to the soil cap system identified. FML and GCL systems have been effectively utilized at a variety of landfill sites.

Figure 4.1 presents the conceptualized areal limits of the landfill cap.

To support the design, the following activities will be conducted and presented in the preliminary design report:

1. an evaluation of alternate capping systems (eg. FML or GCL);
2. an evaluation of minimum and maximum slope requirements;
3. an evaluation of frost protection requirements;
4. assessment of common fill requirements;
5. identification of common fill sources;

6. identification of sand drainage layer sources;
7. identification of clay sources; and
8. identification of top soil sources.

Field activities associated with the landfill capping materials evaluation include:

1. obtaining representative samples of the various soil materials required for construction; and
2. analyzing representative samples for grain size distribution and hydraulic conductivity (and other geotechnical properties, as necessary).

The additional field studies (if required) will be further refined and individually proposed to U.S. EPA for concurrence and approval (if necessary).

#### 4.4 LANDFILL GAS EVALUATION

A landfill gas evaluation will be completed to determine and assess the landfill gas generation characteristics at the Site. These characteristics are required to provide the necessary design information to assess possible designs for a "*A gas venting system capable of removing methane gas build-up beneath the cover*". (SOW, page 2). This evaluation will assess refuse quantities, age and associated properties which control the rate at which landfill gas is generated. The gas venting system shall comply with the substantive requirements of an air quality permit under Michigan Act 348.

##### 4.4.1 Landfill Gas (LFG) Review

This section presents an overview on landfill gas generation theory. This theory will be utilized in support of the pre-design landfill gas evaluation.

#### A. Landfill Gas Composition

The specific composition of landfill gas varies significantly from site to site and even from place to place within a single site. However, it generally has the following constituents:

<i>Parameter</i>	<i>Full Range % by Volume</i>	<i>Anaerobic Decomposition Range % by Volume</i>
1. methane	0% - 70%	40% - 70%
2. carbon dioxide	0% - 90%	30% - 50%
3. hydrogen	0% - 90%	trace
4. oxygen	<1.0%	
5. nitrogen	<2.0%	
6. trace gases	<5%	<5%
a) mercaptans		
b) hydrocarbons (e.g. ethylbenzene, toluene, xylenes)		
c) solvents (e.g. trichloroethene, acetone, 1,1-dichloroethane)		
d) water vapor		
e) hydrogen sulphide		

#### B. Landfill Gas Generation

The decomposition of organic materials contained in landfilled waste results from a combination of biological, chemical and physical processes. Biological decomposition is the most important process in refuse decomposition and the only process to produce methane gas. However, interdependencies among the three processes require that chemical and physical processes also be considered as they directly control the environment that the biological process functions in.

Physical decomposition of landfill waste results from the breakdown or movement of the refuse components by physical degradation and by the rinsing/flushing action of water. Physical saturation of the refuse

causes flow of dislodged refuse particles as a result of pressure gradients and causes diffusion as a result of concentration gradients. As the saturation level of the landfill increases, the rate of water movement increases and increased amounts of refuse particles are dislodged. This results in a more chemically homogeneous refuse mass; which generally causes higher rates of landfill gas generation.

Chemical processes resulting in waste decomposition include the hydrolysis, dissolution/precipitation, sorption/desorption and ion exchange of refuse components. Chemical decomposition generally results in altered characteristics and greater mobility of refuse components thereby enhancing the rate at which the landfill becomes more chemically uniform. The end result of chemical decomposition is that the optimal biological conditions necessary for landfill gas generation are attained more quickly. Thus, chemical decomposition serves to aid biological decomposition and gas generation.

Biological decomposition is a complex process at landfill sites, consisting of various biologically mediated sequential and parallel pathways by which refuse is decomposed completely or partially to various end products. Landfill gas generation results from a number of biological processes that are initiated during refuse generation, collection and placement in a landfill.

Biological decomposition takes place in three stages. Each stage has its own environmental and substrate requirements which result in characteristic end products and effects to be produced.

The first stage takes place when refuse is initially placed in the landfill and some oxygen within the refuse invariably exists. During this stage aerobic micro-organisms degrade organic materials to carbon dioxide, water, partially degraded residual organics and heat. Aerobic decomposition is characteristically rapid relative to subsequent anaerobic stages of decomposition. As a result, the limited available oxygen within the refuse mass is readily depleted. The aerobic micro-organisms produce carbon dioxide levels as high as 90 percent and temperature increases to as high as

40°C. The elevated carbon dioxide results in the formation of carbonic acid in the refuse, thus resulting in acidic pH levels.

The second stage of refuse decomposition involves the facultative micro-organisms which become dominant as the oxygen is depleted. The facultative micro-organisms continue the decomposition process with characteristic end products being high levels of carbon dioxide, partially degraded organics and little production of heat. The production of carbon dioxide and organic acids results in the lowering of the pH of any available moisture, in turn resulting in the dissolution of other organics and inorganics.

After all of the oxygen has been depleted, the third stage of refuse decomposition involving the anaerobic methanogenic bacteria becomes dominant. These organisms produce carbon dioxide, methane and water with little production of heat. Characteristically, these organisms work relatively slowly but efficiently over many years to decompose the remaining organic materials.

Landfills actively receiving refuse will normally undergo all three of these decomposition processes simultaneously. However, typically within the first couple of years following landfill closure, the anaerobic stage becomes dominant and remains so until all the remaining organics have been decomposed. Thus, as the landfill ages, the landfill gas production rates generally decrease.

#### C. Theoretical Landfill Gas Generation Rates

Landfill gas generation rates typically vary as a function of the anaerobic environment available to the methanogenic micro-organisms. Conditions affecting landfill gas generation rates include:

1. refuse composition (as it relates to the rate of decomposition);
2. age of refuse;
3. moisture content;
4. pH;

5. microbial population present;
6. temperature;
7. quantity and quality of nutrients; and
8. other environmental factors.

Moisture content is considered to be the most important of the environmental parameters controlling gas generation rates. The methanogenic bacteria require a minimum subsistence moisture level which is provided by even the driest of landfills. As the moisture level increases and approaches field capacity the gas generation rates are only moderately increased. This is because flow through of water only occurs as the moisture level exceeds field capacity and therefore nutrients, alkalinity, pH, bacteria etc., are not readily transferred throughout the landfill before field capacity has been achieved. After the moisture level exceeds field capacity a flow through of liquid carrying nutrients, alkalinity, pH and bacteria occurs which serves to greatly enhance the landfill gas generation rates. The landfill gas generation rates will increase to the maximum levels as 100 percent saturation of the refuse has been achieved.

The quantity and quality of nutrients available to the methanogenic bacteria will also be a significant factor affecting gas generation rates. The principal nutrients required by the methanogenic bacteria include: carbon, hydrogen, oxygen, nitrogen and phosphorus. In addition to these essential nutrients, the bacterial cells require limited concentrations of trace elements such as: sodium, potassium, calcium and magnesium.

Environmental factors such as pH and temperature also have significant effects on landfill gas generation rates. Methanogenic bacteria require a pH in a narrow range of between 6.7 and 7.2 for optimal gas generation to be achieved. Temperature has also been found to significantly impact landfill gas generation rates. Experimental evidence indicates that by an increase in the temperature of 10°C the rate of bacterial growth may be essentially doubled. In landfill environments temperatures generally range in the 20°C to 60°C range with 43°C being optimal for methanogenic gas production.

#### D. Landfill Gas Production Curve

A useful tool for the evaluation of landfill gas production is a Landfill Gas Production Curve. The production curve is generated for each site individually taking into account the following factors:

1. source of refuse;
2. age of refuse in place;
3. leachate head position;
4. gas production rates in saturated and unsaturated refuse zones; and
5. total gas production.

For the purposes of the G & H Landfill Site, the following constraints shall be utilized to generate a Site-specific landfill gas production curve:

- |    |                      |                                    |
|----|----------------------|------------------------------------|
| 1. | total gas yield:     | 1 to 3 cf (LFG)/lb (refuse)        |
| 2. | gas generation rate: | 0.1 to 0.6 cf (LFG)/lb (refuse)/yr |
| 3. | time:                | 5 to 30 years                      |
| 4. | lag time:            | 2 years                            |

#### 4.4.2 Landfill Gas Evaluation

A landfill gas production curve will be utilized together with Site-specific considerations and a limited field investigation to determine the design requirements (e.g. vent spacing, depth, treatment requirements, etc.) for a landfill gas venting system and the necessity to complete subsequent landfill gas field investigations. The results of the preliminary landfill gas evaluation will be presented in the preliminary design (30 percent) report. The preliminary landfill gas evaluation will include an assessment of the Michigan Air Pollution Act (Michigan Act 348) requirements. These requirements include:

1. Evaluating the emission rates of landfill gas constituents (see Section 4.4.1, Part A) including:

- methane,
  - carbon dioxide,
  - volatile organic compounds (VOC);
2. Evaluating individual landfill gas constituent concentrations including:
    - methane,
    - carbon dioxide,
    - Target Compound List (TCL) VOC;
  3. Evaluating the potential risks associated with the emission or migration of landfill gas constituents to potential off-Site receptors, the risks will be evaluated on a Site-specific basis at the property line (or beyond) following the MDNR Air Quality Division assessment procedures; and
  4. Evaluating Best Available Control Technology (BACT) to control landfill gas emissions or migration should the potential risks associated with the emissions or migration be determined to be unacceptable.

The landfill gas venting system will be designed to comply with the substantive requirements of Michigan Act 348 including the substantive requirements of a Michigan Act 348 Air Use Permit.

The preliminary landfill gas evaluation presented in the 30 percent design submittal will include an assessment of the landfill gas data presented in the U.S. EPA RI and MDNR Supplemental Investigation (SI). During Stage II of the RI and the SI the following gas probes were installed:

### *RI Stage II*

1. GP-01
2. GP-02
3. GP-03

### *MDNR SI*

1. GP-107
2. GP-108
3. GP-110
4. GP-111
5. GP-116
6. GP-117
7. GP-118
8. GP-119
9. GP-120

These gas probes will be monitored during the preliminary field investigation as discussed below in Section 4.4.3. The preliminary monitoring results will also be presented and evaluated in the 30 percent design submittal.

The landfill gas evaluation presented in the 30 percent design report will present an evaluation of landfill venting requirements (including treatment). This evaluation will be based upon a theoretical evaluation supplemented by the preliminary field investigation. It should be noted that the actual requirement for landfill gas treatment will be based upon the actual emissions determined to be emanating from the gas vents.

#### 4.4.3 Field Studies

Landfill gas field studies will be conducted utilizing a phased approach as outlined below:

- Phase I: Preliminary Landfill Gas Field Investigation  
Phase II: Landfill Gas Field Investigation (if required)

During the Phase I preliminary field investigation the following field studies will be completed:

- reconnaissance of existing gas probes (GP-01, 02, 03, GP-107, 108, 110, 111, 116, 117, 118, 119, 120);
- monitoring of intact gas probes for the following:
  - gas pressure,
  - methane,
  - oxygen,
  - explosive gas,
  - total VOC;
- landfill perimeter gas survey:
  - reconnaissance of Phase I, II and III landfill perimeters,
  - surficial gas survey for methane, oxygen, explosive gas and total VOC (survey will be completed by punching holes approximately 2 to 4 feet deep with a steel rod and sledge hammer, various gas monitoring instruments would be utilized to determine the presence of landfill gas constituents).

The results of the Phase I preliminary landfill gas field study will be presented and evaluated in conjunction with the landfill gas evaluation discussed in Section 4.4.1. Together, the preliminary evaluation and field study will be presented in the 30 percent design submittal. The preliminary evaluation presented in the 30 percent design report will identify the necessity of completing a Phase II Landfill Gas Field Investigation to provide the supplementary information necessary to complete the landfill gas venting system design (if required).

#### Phase II: Landfill Gas Field Investigation (if required)

The Phase II field investigation will be conducted dependent upon the results of the Phase I field investigation and evaluation presented at the 30 percent design stage. The Phase II investigation work plan will be presented in the 30 percent design report. The scope of work for the Phase II investigation may include the sampling of existing gas probes for individual TCL VOCs (or related compounds) in addition to the installation and sampling of additional gas probes.

The Phase II investigation will focus on determining the VOC concentrations in the landfill gas in support of the evaluation of the levels which may be emitted from the gas vents. The Phase II investigation will be utilized to focus any remaining design issues for subsequent design activities (eg. 95 percent design).

#### 4.5 WETLANDS EVALUATION/MITIGATION PROGRAM

A preliminary wetlands evaluation of the G & H Landfill Site resulted in the determination that wetland resources on the Site are subject to protection and restoration under the Goemaere-Anderson Wetlands Protection Act, P.A. 203 of 1979.

The SOW has identified the task of wetland mitigation as a component of the remedial action for this Site and requires the development of a Wetlands Mitigation Plan for wetland restoration as part of the RD effort.

The following outlines a phased approach to conducting a wetlands inventory which will be utilized in conjunction with the 30 percent cap design to determine wetlands mitigation requirements.

##### Phase I: Wetlands Inventory

The first phase of a wetlands mitigation program involves the completion of a detailed identification of the wetlands on the Site combined with a characterization of the specific type of wetland resources present. This activity must be completed early in the design phase to allow a determination to be made as to the level of effort required to protect, restore and/or replace the wetlands involved.

The evaluation will require the on-Site inspection of the wetland habitats to document the constituent organisms and the hydro-dynamics of the various systems encountered. This evaluation will result in the preparation of a detailed inventory of these resources which will

be compiled with existing information and data currently held by the MDNR or U.S. EPA.

This effort will result in the preparation of a detailed map and inventory of wetland resources at the Site. The wetlands inventory will serve as the prime reference and basis of the future planning and development of a wetlands mitigation program.

### Phase II: Wetlands Mitigation Plan

The second phase of the wetlands mitigation program is to identify the various areas which will be subject to some type of impact by remediation activities. These impacts range from no significant impact to complete ecosystem elimination as the landfill cap construction progresses. Once these areas of impact are determined (i.e. during preparation of the 30 percent design), engineering considerations may be brought into the design of mitigation measures. These may include, but are not limited to, re-establishment of aquatic ecosystems, development of alternative drainage schemes to provide for the establishment of wetlands at alternative locations (such as within on-Site fill borrow areas (i.e. junkyard)) on the Site, or the creation of new wetland resources at another location to replace those eliminated at the Site. In addition, it should be noted that wetlands may be created during the removal of contaminated sediments identified during the Soil/Sediment Sampling Program (see Section 4.12). The application of drainage and hydraulic engineering expertise at this point is critical to the preservation of as much native aquatic resources in this location as possible while also addressing the effectiveness and security of the cap over the fill areas.

The results of the engineering analysis and the on-Site inventory will be incorporated into the development of a Wetlands Mitigation Plan which will present the necessary activities to protect existing communities while introducing those specimens and substrates necessary to establish alternative aquatic habitats which are stable and biologically effective. The precise scope of this remediation plan cannot be determined until an accurate inventory of the on-Site conditions has been completed.

This Wetlands Mitigation Plan will serve as the basis for the later implementation of wetlands mitigation actions.

#### 4.6 SOURCE CONTAINMENT SYSTEM EVALUATION

As identified within the SOW, the source containment system may be comprised of either a groundwater collection drain or a series of extraction wells. If a collection drain is selected the SOW allows the option of utilizing a downgradient slurry wall or flexible membrane liner (FML) to prevent the dewatering of the upper sand aquifer or wetlands downgradient of the source containment system. If the source extraction wells are utilized, the SOW specifies that a slurry wall be constructed.

Additional pre-design activities are not required to support the design of the source containment system. However, information obtained from the boreholes to be completed along the slurry wall alignment will be used to help support the design of the source containment system (see Section 4.7). The borehole investigation will provide geotechnical data and will allow the depth to the lacustrine clay/till beneath the Site to be better defined.

The selection of the source containment system consisting of either the collection trench with downgradient barrier (slurry wall or FML) or the gradient control extraction well network with a downgradient slurry wall will be based on a pre-design evaluation focused on design requirements, performance criteria, constructability and cost.

The results of the slurry wall alignment borehole investigation will be utilized in evaluating each alternative.

#### 4.7 SLURRY WALL DESIGN PROGRAM (SWDP)

The Source Containment System will be comprised of either a series of source extraction wells or a collection drain and an associated

slurry wall or vertical flexible membrane liner (FML). This section provides the necessary procedures required to assess the design and suitability of a slurry wall should it be required as part of the Source Containment System. The design approach presented in this section will not be required if a source collection drain is selected with a FML. If the collection drain and FML is selected, the stratigraphy along the alignment of the system will be evaluated by completing the boreholes identified in Task SWDP4.

As discussed in Section IIB of the SOW (Source Containment System), a subsurface vertical barrier wall (i.e. slurry wall) may be constructed along the southern perimeter of the Phase I and II landfill areas, and the oil seep area. The SOW states that *"The slurry wall shall be a minimum 2.0 feet thick and have a maximum hydraulic conductivity of  $1 \times 10^{-7}$  cm/s. The slurry wall shall be keyed into the lacustrine/till unit beneath the Site, with a minimum of 3.0 feet of the slurry wall to be constructed into the lacustrine/till unit,"* (SOW, page 3).

The SOW further states that a materials testing program be undertaken to determine the compatibility of slurry wall materials with Site groundwater or leachate. The SOW states that: *"Settling Defendants shall design and, upon U.S. EPA approval, implement compatibility testing of the slurry wall construction materials with chemical compounds associated with the landfill. Testing shall evaluate the effects of concentrations of the landfill contaminants (i.e. oil) noted in the RI report (Table 3-3), on the effectiveness of the slurry wall construction materials. Compatibility test results shall be submitted to U.S. EPA for review. If U.S. EPA, in consultation with MDNR, determines that high concentrations of hazardous substances are likely to increase the hydraulic conductivity of the slurry wall to greater than  $1 \times 10^{-7}$  cm/s, then Settling Defendants shall utilize oil/water extraction wells to prevent the migration of oil and solvents towards the slurry wall."* (SOW, page 7).

The purpose of the Slurry Wall Design Program is to collect all of the necessary data and information required to complete the slurry wall design. The following sections provide an overview of slurry wall construction techniques and organic chemical/clay interaction. The purpose

of this discussion is to provide the basis to allow the slurry wall materials testing program to be effectively designed.

#### 4.7.1 Overview

Underground vertical barriers (cutoff walls) have been used to prevent the lateral migration of aqueous (APL) and/or non-aqueous phase (NAPL) contaminants at waste disposal sites. A common and relatively simple method of providing this containment involves the design and construction of a soil-bentonite slurry cutoff wall (slurry wall). Cutoff walls using the slurry trench method of construction were first constructed in the United States in the early 1940s (D'Appolonia, 1980). Since that time, several hundred slurry walls have been constructed for both temporary and permanent control of seepage into foundations and excavations and in recent years, to prevent the migration of contaminants away from waste disposal sites.

Slurry walls have been in common use since the mid 1970s, but the general engineering community has been slow in the acceptance and use of the technique. For the most part, the engineering community is not up to date with the latest design and testing approaches. ASTM is only now beginning to produce relevant standards for slurry wall testing and as a result there are no generally accepted standard of practice for slurry wall construction (Ryan, 1987).

Slurry walls have many advantages over traditional containment methods, such as deep-rolled fill cutoffs, grouted cutoffs, and sheet pile cutoffs. These advantages include cost savings, ease of construction and reliability. Despite the increasing rate of the use of the method only a very limited data base exists concerning the engineering properties of slurry walls or the performance of completed field installations.

Remedial actions represent the bulk of the applications of slurry cutoff walls for the control of contaminant migration. Several of the

Superfund sites completed to date have utilized vertical cutoffs barriers as a component of the site remediation.

A review of the literature indicates that the use of groundwater cutoff walls at hazardous waste sites has been increasing in recent years. It is expected that groundwater cutoff walls will form a common component of remedies at hazardous waste sites throughout the 1990s.

As in any engineering project, there are a series of steps that are completed in order to select a groundwater slurry wall design. These include identifying and evaluating the following:

- design objectives;
- performance requirements;
- geometry; and
- environmental considerations.

In the hazardous waste management field, the primary objective of a groundwater cutoff wall is to contain site-related contaminants in order to reduce site impacts on the groundwater environment.

Other objectives may include creating a diversion so as to minimize groundwater flow through contaminated zones and/or to allow a groundwater extraction system to be designed that can minimize pumping requirements in order to reduce both the size and costs of a pump-and-treat system.

In summary, the objectives of groundwater cutoff walls at hazardous waste sites may include:

- providing containment of groundwater contamination;
- providing a groundwater capture environment that reduces pumping requirements;
- providing a groundwater diversion; and
- reducing overall remedial costs.

The primary performance requirements for groundwater cutoff walls are that of low hydraulic conductivity and durability. Secondary performance requirements may include strength and flexibility. These properties are present to varying degrees in all of the alternative cutoff wall designs.

In the hazardous waste management field, groundwater cutoff walls are usually required/designed to have a maximum hydraulic conductivity of  $10^{-7}$  cm/sec. In order to assure containment of contaminants, a groundwater extraction system is often installed inside the area surrounded by the groundwater cutoff. Groundwater is removed at a rate sufficient to ensure that an inward hydraulic gradient exists around the perimeter of the cutoff.

### Slurry Wall Cutoffs

Slurry walls are the most common form of groundwater cutoffs designed for implementation at hazardous waste sites. The term slurry wall is applied to a variety of cutoff walls all having one thing in common, they are constructed in a vertical trench that is excavated under a slurry. The bentonite-water (BW) slurry acts to shore the trench to prevent collapse and also forms a filter cake on the trench side walls which acts to prevent fluid losses and reduces the native soils hydraulic conductivity (the filter cake permeability may be on the order of  $10^{-7}$  to  $10^{-9}$  cm/sec).

In brief, the trench is excavated, immediately filled with BW slurry and subsequently backfilled with soil-bentonite (SB), soil-attapulgate (SA) or some other suitable backfill. The typical SB construction methodology is presented on Figure 4.2. In some cases, the trench is excavated under a slurry of cement, bentonite and water. In this case, the cement-bentonite (CB) mixture is left in the trench to set. SA backfill is a relatively new backfill which may gain acceptance in the near future. Attapulgate clay is a non-reactive clay which appears to be more resistant to chemical attack than reactive swelling clays such as bentonite. In some cases, where great strength may be a requirement, pre-cast or cast-in-place concrete may be used to form a rigid "diaphragm wall".

Each of the following types of slurry wall is discussed below:

- A. soil-bentonite (SB);
- B. cement-bentonite (CB); and
- C. soil-attapulgite (SA).

A fourth material which could have an application for this Site would be organophillic clay (bentonite) soil wall. Organophillic clays have been designed to swell in the presence of hydrocarbons. These bentonites have been used for some time by the drilling industry which uses diesel fuel to drill through formations soluble in water (salt). Most of the leading research on organoclay has been carried out in Europe, however, American Colloid in combination with Michigan State University, has recently been studying the use of blended organophillic clay-bentonite mixtures for soil liners and cutoff wall applications (Boldt-Leppin, 1993). This bentonitic clay may have potential applications for containing both the movement of water and hydrocarbons from this Site. This material will be further evaluated during the pre-design (as required).

A. Soil Bentonite (SB) Cutoff Walls

SB slurry walls are the most common form of groundwater cutoff walls utilized for contaminated groundwater containment. SB slurry walls offer advantages including low costs, low permeabilities and the widest range of chemical compatibilities.

The key components of a SB cutoff wall include the bentonite-water (BW) trenching slurry and the soil-bentonite (SB) backfill. Design specification ranges for each of these key components are presented below.

#### A.1 BW Trenching Slurry

As previously discussed, the purpose of the BW trenching slurry is to maintain the stability of the excavated trench throughout construction. This requires the slurry to have specific viscosity, gel strength and density requirements. These are summarized below:

1.	Bentonite %	4 to 7 (Boyes, 1975)
2.	Water %	93 to 96 (Boyes, 1975)
3.	Density	1.01 to 1.04 g/cm <sup>3</sup> (Case, 1982)
4.	Apparent Viscosity	38 to 45 Marsh seconds (Case, 1982)
5.	Filtrate Loss	<30 mL (Jefferies, 1981)
6.	pH	7.5 to 12 (Boyes, 1975)
7.	Gel Strengths (@ 10 minutes, Pascal)	7 - 30 (Boyes, 1975)

#### A.2 SB Backfill

The BW trenching slurry is replaced by a SB backfill which is essentially a remolded soil with bentonite added in a significant amount to affect a permeability decrease. Key design factors are specified as follows:

1.	Native Soils %	60 to 80
2.	Fines % (minus 200) (plastic fines are preferable)	20 to 40
3.	Gravel % (3/4" + 3")	10 to 20 (xanthakoo, 1979)
4.	Water Content % (10 to 15 cm slump)	25 to 35
5.	Bentonite Content %	1 to 5 (D'Appolonia, 1980; Tang, 1987)

#### B. Cement Bentonite (CB) Cutoff Walls

The principal difference between SB and CB slurry walls is that of the backfill. CB walls are excavated using slurries composed of cement, bentonite and water. The difference is that the slurry is left to set up to form the completed cutoff wall. CB walls are generally more expensive

than SB walls and are not capable of providing as low hydraulic conductivities as SB cutoffs. In general, the hydraulic conductivity of CB walls is usually around  $10^{-6}$  cm/sec. CB walls are also more susceptible to contaminant attack. As with cements/concrete in general, CB cutoff walls are susceptible to attack by sulfates, strong acids and bases ( $\text{pH} < 4$ ,  $\text{pH} > 7$ ) and other high risk substances. Compositional ranges for CB cutoffs are as follows:

bentonite	4% to 7%
water	68% to 88%
cement	8% to 25%
slag	7% to 22%
flyash	6% to 18%
others:	accelerators, retardants or additives

CB walls are more expensive than SB walls and, therefore, are generally not used at hazardous waste sites unless:

- there is no room to mix SB;
- increased physical strength is required; or
- extreme topography makes it impractical to grade the site for a SB cutoff wall installation.

### C. Soil-Attapulgate (SA) Cutoff Walls

A relatively new method of backfilling a slurry wall to provide low hydraulic conductivity at hazardous waste sites involves the placement of SA backfill. SA backfill may be chosen as an appropriate backfill when traditional bentonite backfills are found to be adversely affected by site contamination. SA has had only limited field use as it is an emerging technology.

Attapulgate clay consists of "needle-like" silicate clay mineral as opposed to the "plate-like" structure of bentonite. This physical characteristic gives attapulgate clay a low ion exchange capacity and thus it is relatively resistant to chemical degradation. However, attapulgate does not have the swelling characteristics of bentonite and thus larger percentages of

attapulgate are required in the backfill to provide a similar low hydraulic conductivity of that of bentonite-based backfills.

### SUMMARY

In summary, there are three backfill candidate materials which are available for use in the backfill design at the Site. These include:

1. Soil Bentonite (SB);
2. Cement Bentonite (CB); and
3. Soil Attapulgate (SA).

The utilization of one or more backfills at the Site will be dependent upon construction requirements and the demonstrated effectiveness of a specific material. To this end, a SWDP has been developed to provide the necessary information prior to the initiation of slurry wall design activities.

#### 4.7.2 Scope

The Slurry Wall Design Program (SWDP) is comprised of a number of tasks which may be required to:

1. define the stratigraphy along the slurry wall alignment;
2. collect soil samples for grain size analysis and subsequent slurry wall backfill design and durability testing;
3. conduct trenching slurry durability testing;
4. conduct slurry wall backfill design testing; and
5. conduct slurry wall backfill durability testing.

The SWDP is comprised of a number of tasks which were developed in a manner consistent with the U.S. EPA guidance document entitled "Slurry Trench Construction for Pollution Migration Control" (EPA-540/2-84-001) and other pertinent technical literature. In addition to specific technical guidance, the SWDP has been developed based upon the

experience of Dr. Moir Haug, an expert in the field of slurry wall construction. The SWDP will be comprised of the following tasks:

Task SWDP1	Detailed Site Inspection
Task SWDP2	Procurement of Subcontractors
Task SWDP3	Site Survey and Base Map
Task SWDP4	Subsurface Soil Investigation
Task SWDP5	Groundwater Investigation
Task SWDP6	Slurry Wall Materials Evaluation
Task SWDP7	Slurry Wall Laboratory Testing Program
Task SWDP8	SWDP Report

Each of the above identified tasks is discussed in the following subsections.

#### 4.7.2.1 Task SWDP1 - Detailed Site Inspection

A detailed Site inspection to evaluate and assess the present conditions of the Site and to confirm the locations for all sampling activities will be conducted. Access to sampling locations and soil sampling equipment needs, will be reassessed during the Site inspection.

#### 4.7.2.2 Task SWDP2 - Procurement of Subcontractors

Final procurement of subcontractors will occur after the RD/RA Work Plan has been approved by U.S. EPA. It is expected that the following subcontractors will be required:

1. Land Surveyor - licensed State of Michigan land surveyor;
2. Soil Borings - qualified drilling company;
3. Chemical Analysis - qualified and approved laboratory; and
4. Geotechnical Analysis - qualified and approved laboratory.

All SWDP protocols, regulations, procedures and guidance documents agreed upon between Group and U.S. EPA will be

applied to all subcontractors retained by the Engineer during the implementation of the SWDP. The Engineer will manage and coordinate all field activities completed by subcontractors.

#### 4.7.2.3 Task SWDP3 - Site Survey and Base Map

##### A. Site Survey

The Engineer will retain a licensed State of Michigan land surveyor to perform a total station survey of the slurry wall alignment using accepted land survey methods and equipment. An accurate base map shall be developed to support all investigative and design activities. All survey data and notes will be forwarded to the Engineer and placed into the project files. In addition, all sampling points will be surveyed and plotted on the base map. The survey will provide the necessary information to develop slurry wall alignment profiles.

##### B. Base Map

The Engineer will compile the data obtained from the surveyor and prepare a base plan and a contour plan showing all details pertinent to the Site. The survey will provide additional data which will be tied into the existing plan for the Site. All data will be stored on a computerized system allowing further data to be readily incorporated as received.

#### 4.7.2.4 Task SWDP4 - Subsurface Soil Investigation

A subsurface soil investigation will be conducted along the proposed slurry wall alignment to:

1. define the stratigraphy;
2. collect soil samples for grain size analysis and subsequent slurry wall backfill design and durability testing; and

3. collect groundwater samples for analytical characterization and subsequent backfill testing.

It is expected that this activity will require the drilling of 14 boreholes (on approximate 200-foot centers). The proposed slurry wall alignment and the approximate locations of the 14 boreholes are presented on Figure 4.3. The borehole locations were selected to supplement available borehole stratigraphic information from the RI. In general, additional boreholes were located to ensure that stratigraphic information was available at approximate 200-foot centers along the slurry wall alignment. The exact locations of the boreholes, within the proposed layout, may have to be slightly modified to account for obstructions or severe topography. Additional boreholes may be completed if it is determined that there is insufficient definition of the stratigraphy along the slurry wall alignment.

Boreholes will be advanced by means of a drilling rig equipped with hollow stem augers. Continuous soil sampling (to provide a geologic record) will be conducted at five of the boreholes. Due to the fact that the Site stratigraphy was previously characterized during the U.S. EPA Remedial Investigation (RI) the remaining boreholes will be sampled to provide a geologic record at 5-foot intervals. Geologic sampling intervals on the remaining boreholes may be made smaller during the drilling program (especially at the sand/clay interface). This determination will be dependent on the findings of the field drilling program as it proceeds. Sampling will extend in all boreholes to a minimum of 10 feet below the surface of the lacustrine till layer (a depth of approximately 20 to 30 feet). The stratigraphic information provided by this activity will allow detailed alignment profiles to be developed for the design package.

The depth of the key is anticipated to be approximately 3 feet into the clay unit. This distance is usually sufficient, however, the upper surface of the lacustrine unit/till may be fractured. This fracturing may have been caused by changes in stress, freeze-thaw or desiccation. Any of these processes could make the upper portion of the potential aquiclude permeable. Thus, the stratigraphic drilling will also include collecting undisturbed continuous samples of the proposed key area in a number of

boreholes. The undisturbed samples will be visually examined for any signs of weathering (iron staining or cracks).

The subsurface investigation will also evaluate zones in the boreholes that contain organics (to soil, peat, etc.) Such material will have to be excavated, wasted and replaced with "clean" fill. Soil containing organic material lowers the hydraulic conductivity and density of SB backfill material and results in increased settlement of the wall. This type of settlement can lead to arching along the trench wall and the creation of voids. As a result, organic material will be excluded from the materials to be blended into the backfill.

All samples will be collected by means of a split spoon sampler (as described in ASTM D 1586) driven into the ground 24 inches at a time. If the soil has the tendency to fall out of the split spoon sampler while being retrieved, a clean basket retainer will be used. In order to obtain the necessary quantities of soil for subsequent testing requirements a 3-inch diameter split spoon will be utilized.

Following the collection of soil samples which provide the geologic record of the borehole the split spoon sampler will be cleaned as follows:

- (a) clean off any gross contamination with a stiff brush;
- (b) wash and scrub using laboratory grade non-phosphate detergent; and
- (c) rinse with deionized water.

This procedure will allow the split spoon samplers utilized for collecting the geologic record samples of the borehole to be rapidly cycled back to the driller for the continuation of the drilling of the borehole.

The hollow stem augers will be cleaned at the start and end of the project and between boreholes by high pressure steam cleaning. Steam cleaning will be conducted at the on-Site decontamination facility.

Following retrieval of the individual split-spoon samples, the soil samples will be immediately screened with a photoionization device (PID) (e.g. HNu) as the split spoon is opened. A log of PID readings shall be maintained for each borehole. Samples will then be carefully examined by an experienced Geologist/Engineer for color, soil type, stratigraphy, banding, moisture, odor, signs of contamination and any other identifying feature. The top two inches or any part of the upper sample which appears to be soil carried or fallen from the upper levels of the boreholes will be immediately discarded. The sample will then be photographed (if required to document the sampling technique) and placed in sample jars to provide a geologic record of the borehole.

The geologic samples will be sequentially numbered as the borehole advances. The location and number of the geologic sample shall be recorded on the borehole log.

At the completion of each borehole the geologic samples shall be placed in sample boxes and moved to the on-Site support trailers. After a minimum of approximately 15 minutes (to allow for soil/air equilibrium to be achieved) a PID shall be utilized to obtain headspace organic vapor readings on all of the geologic samples collected from the completed borehole. Headspace PID readings shall be compiled for all boreholes in a tabular format. The PID readings will provide a relative indication of the possible presence of organic chemicals along the slurry wall alignment. This information will benefit subsequent slurry wall backfill design and durability testing.

It should be noted that it is equally important that the backfill be well graded with sufficient coarse materials to lower the porosity (Grube, 1993). A well graded low porosity backfill has a low hydraulic conductivity and minimal settlement. High fines in a poorly graded backfill can result in excessive trench settlement following construction. This can lead to subsequent arching after backfilling (Spooner, 1985). Thus, it may also be necessary to find or import coarse material (Haug, 1992) in order to ensure that the backfill material is sufficiently well graded and minimum settlement takes place (Mitchell, 1976).

During the completion of the boreholes one soil sample from each borehole may be collected for Target Compound List (TCL) VOC, SVOC and PCB/Pesticide analysis. Additions or deletions to the soil samples which may be collected for chemical analysis will be based upon the field conditions encountered as well as the results of the PID screening of split spoons and on PID head space analyses.

Samples for chemical analysis shall be placed in sample jars as described in the QAPP. Samples for VOC analysis shall not be composited.

All samples shall be shipped to the laboratory via overnight courier under Chain-of-Custody procedures.

Prior to and following retrieval of individual samples for chemical analysis, the split spoon sampler will be cleaned as follows:

- (a) clean off any gross contamination with a stiff brush;
- (b) wash and scrub with laboratory grade non-phosphate detergent;
- (c) rinse with potable water;
- (d) rinse with methanol;
- (e) thoroughly rinse with deionized water;
- (f) air dry in dust/contaminant free atmosphere;
- (g) place cleaned equipment on polyethylene sheeting or aluminum foil in order to avoid contacting a contaminated surface; and
- (h) wrap in aluminum foil.

Grain size analyses will be conducted on approximately two to four samples from each borehole (dependent upon changes in stratigraphy). The grain size information is required to support the backfill design.

A weighted average for the percent fine grained material will then be calculated at each borehole location, based upon the thickness of

each of the stratigraphic units and the grain size analysis results for that unit. The following equation will be utilized:

$$\frac{T_1P_1 + T_2P_2 + T_3P_3 + T_4P_4 + \dots + T_nP_n}{T_1 + T_2 + T_3 + T_4 + \dots + T_n} = P_{ave}$$

where:

T is the thickness of the stratigraphic unit;

P is the percentage of the fine-grained material for the stratigraphic unit; and

1, 2, 3, 4, ..., n represent different stratigraphic units.

The percentage of fine grained material in the soils between adjacent boreholes A and B will then be calculated based upon the average percentage of the combined A and B borehole locations, as follows (premised on equal borehole spacing):

$$\frac{D_A P_A + D_B P_B}{D_A + D_B} = P_{AB}$$

where:

$D_A$  is the depth of the barrier wall at borehole location A;

$P_A$  is the average percentage of fine grained material at borehole location A;

and

A and B designate adjacent borehole locations A and B.

A target level of 25 percent fine grained material will be used for backfill design purposes.

It should be noted that it is equally important that the backfill be well graded with sufficient coarse materials (e.g. gravel) to lower the porosity (Grube, 1993). A well graded low porosity backfill has a low hydraulic conductivity and minimal settlement. High fines in a poorly graded backfill can result in excessive trench settlement following construction. This can lead to subsequent arching after backfilling (Spooner, 1985). Thus, it may also be necessary to find or import coarse

material (Haug, 1992) in order to ensure that the backfill material is sufficiently well graded and minimum settlement takes place (Mitchell, 1976).

During the completion of the drilling activities the Engineer shall collect soil materials from each borehole for subsequent use in the backfill testing. It is currently expected that approximately 100 pounds of soil per borehole should be collected for subsequent testing. The quantity of soil collected for each borehole should be representative of the borehole length in the upper sand. The soil material should be placed in appropriate containers (i.e. drums) for subsequent transport to the geotechnical laboratory. Additional soil material will be collected, as necessary.

#### 4.7.2.5 Task SWDP5 - Groundwater Investigation

During the course of the field sampling program, groundwater samples will be collected from selected monitoring wells for subsequent use as a permeant in the trenching slurry and backfill durability testing phases of the project. It is currently anticipated that groundwater samples would be collected from the following monitoring wells:

1. GH-05A;
2. GH-12A;
3. GH-19A; and
4. GH-21A.

These monitoring wells are located upgradient of the proposed slurry wall alignment and therefore should conservatively approximate the contaminant levels which may be in contact with the slurry wall backfill. Alternative methods of obtaining permeants may be evaluated during the implementation of this task.

A sufficient volume (e.g. 55 gallons) of groundwater from each of the wells will be collected for transport to the geotechnical laboratory. The groundwater will be collected utilizing a submersible pump. The

groundwater will be pumped into a 55-gallon drum equipped with a plastic drum liner. The groundwater will be collected to ensure minimal loss of VOCs while filling the drum. The water will be filled such that there is zero head space within the drum. After receipt at the geotechnical lab the drum will remain in cold storage at less than 4°C. The drum will remain sealed and in cold storage except to collect water for laboratory testing.

In addition, the groundwater and tap water to be utilized during the testing program will be analyzed for the following constituents:

1. TCL/TAL analytes;
2. pH;
3. hardness; and
4. calcium, sodium.

All sampling and analytical procedures shall be conducted as identified in the SAP, QAPP and HASP.

#### 4.7.2.6 Task SWDP6 - Slurry Wall Materials Evaluation

At the completion of the subsurface soil and groundwater investigations, the data will be tabulated and evaluated to finalize the slurry wall materials to be tested during subsequent tasks.

The selection of slurry wall materials is discussed in the following paragraphs:

- A. Site Soils
- B. Backfill Materials

A. Site Soils

The suitability of the native soils along the slurry wall alignment for utilization in the slurry wall backfill will be ascertained based upon a review of the grain size information as well as the chemical analyses. Criteria for judging the suitability of the native soils for inclusion in the slurry wall backfill design include:

1. grain size distribution
  - need minimum of 20 to 40 percent fines (25 percent goal)
  - plastic fines are preferable
2. adverse chemistry
  - presence of APL
  - presence of NAPL

Based upon the information provided in the RI, the upper sand unit is described as fine to gravelly sand with trace silt and clay. Along the slurry wall alignment, it is expected that the native upper sand may contain on the order of 10 to 20 percent fines. This may require that additional fines be added during construction to meet the preferred design specification of 25 percent fines. In addition, it will be necessary to assess the percentage of coarse materials available and required in the backfill (3/4" to 3" gravel at 10 to 20 percent)

If it is determined that additional fines or gravel are required for the backfill, the Engineer will identify and evaluate potential sources (e.g. silty fines generated at a gravel washing operation and gravel). The Engineer will verify the availability of sources of the fines/gravel and collect samples for grain size analysis. In addition, the Engineer shall obtain a sufficient quantity for subsequent testing (approximately a 3/4 full 55-gallon drum of each material).

A review of the available analytical data provided in the RI indicates that seriously adverse chemistry is not expected along the proposed slurry wall alignment (see paragraph B below).

The soil and groundwater samples collected during Tasks SWDP4 and SWDP5 will provide the additional information necessary to resolve data gaps and design issues.

B. Backfill Materials

Slurry wall backfill materials include appropriate clays, fines and hydrating fluids (i.e. water). The following provides an overview of the effects of organic chemical/clay particle interaction. The literature review is utilized to further scope the proposed slurry wall backfill material testing.

Literature Review

The following literature review presents a description of physical and chemical mechanisms which may result in the failure of soil bentonite backfills and evaluates the potential for these problems to occur given the Site-specific conditions of the slurry wall installation at the G & H Landfill Site.

One cause of clay barrier failure is widely recognized to be associated with the alteration of the diffuse double layer (Gouy-Chapman Theory reviewed by Van Olphen, 1977 and Mitchell, 1976) of the clay particles. The thickness of this layer will decrease (for bentonite clays) as the dielectric constant of the pore fluid surrounding the clay decreases. The thickness will also be affected by electrolyte concentration and the valence of the electrolytes in the porewater. The normal dielectric constant of pore water is 80.4 (Flick, 1985). Most organic chemicals have much lower dielectric constants such as xylene (2) and phenol (approximately 15). If these organics are present in concentrated form (i.e. dielectric constant less than 30), the clay will lose its plasticity and the hydraulic conductivity will increase three to four orders of magnitude (Acar and Seals, 1984). Where the organic compounds are aqueous phase (i.e. dilute concentration), very little effect has been observed. Daniel et al (1988) tested clays with a solution of industrial waste leachate with a concentration of 1,440 mg/L and found a negligible effect to both the dielectric constant and the permeability of the bentonite. Similar results were

also reported for xylenes which is one of the most predominant chemicals at the Site, by Daniel et al at its solubility limit in water, which is 196 mg/L. The conclusion, as stated by Daniel et al, determined that:

*"Permeability tests showed that none of the liquids caused a significant increase in hydraulic conductivity (K). A gradual reduction in hydraulic conductivity (K) with time was observed in most tests. The lack of any increase in K was the result of the fact that the properties of dilute organic liquids are controlled by the dominant compound (water). In particular, the dielectric constant of aqueous solutions containing small amounts of organic chemicals is approximately equal to the value for water. Hence, unlike concentrated organic chemicals (with low dielectric constants), which cause large increases in K, dilute aqueous solutions containing organic chemicals seem incapable of causing significant changes in hydraulic conductivity of the liquid unless some characteristic of the liquid besides organic content (such as electrolyte concentration or valence) causes an increase."*

Another factor which affects the diffuse double layer is the basal d-spacing of the clay particles. Barshad (1952) found that increasing the dielectric constant also increased the basal d-spacing which caused swelling of the clay to occur. This increase in basal d-spacing (swelling) will decrease the permeability of clay. Brindly (1969) and Brown, Thomas and Green (1984) found that dilute solutions of polar organics were found to increase the basal d-spacing of the clays, while concentrated solutions were found to decrease the basal d-spacing, relative to the value obtained with pure water. Griffen et al (1984) found that water clay slurries exposed to water-immiscible carbon tetrachloride showed no change in basal d-spacing, suggesting that water-immiscible fluids have no effect on the d-spacing of smectitic clays.

Another factor in the stability of the clay barrier is whether the compounds can penetrate the surface tension forces of the media. Multi-phase flow theory (reviewed by Bear, 1972) predicts that surface-tension forces will prevent a water-immiscible organic fluid from entering into the small pore spaces of water-saturated bulk clay except under high entry pressures (high head differentials). Entry of the water-immiscible

organic fluids will occur under the expected head differentials only if fractures or macropores are present in the clay. This should not occur at this Site with the soil/bentonite backfill.

The results of research on the permeation of water-wet clays with the aqueous phase of water-immiscible organic chemicals have been in good agreement and show no changes in hydraulic conductivity for any of the tests (Daniel et al, 1988; Bowders, 1985; Acar et al, 1985; Evans et al, 1985). This lack of change is consistent with double layer theory as dilute solutions of these organic chemicals do not have a dielectric constant lower than that of pure water. Also, the results of studies conducted at Louisiana State University (1984) indicate that even at a hydraulic gradient of 150, benzene did not permeate through compacted bentonite. Similar results were reported by other researchers. These results indicate that under field gradients it might be practically impossible to permeate immiscible organics through water-saturated clay.

Mesri and Olson(1984) found that K was several orders of magnitude higher for clays that were sedimented from suspensions containing concentrated organic chemicals compared to materials sedimented in water. Daniel et al (1988) found that dilute organic liquids caused little alteration (small decrease) in the hydraulic conductivity of clay soils. Therefore, as predicted by the diffuse double layer theory, dilute concentrations of chemicals (i.e. less than five percent), will not affect the sedimentation of clay in the slurry, whereas high concentrations may have a potential impact.

pH can also be a contributing factor in the breakdown of a clay barrier. Dramatic increases in hydraulic conductivity were noted at low and high pH values. Low or high pH values may also produce effects other than changes in the forces of interaction. Keller (1964) demonstrated that solubility of alumina and amorphous silica is greatly increased if the pH of the solution is less than 5 or greater than 8. Therefore, the clay minerals may dissolve in solutions of pH outside the range of 5-8. This is confirmed in studies by Acar et al (1984).

Decreasing electrolyte concentrations can also result in increases in hydraulic conductivity as demonstrated by Hardcastle and Mitchell (1976), Quirk and Schofield (1955) and Blackmore and Marshall (1965).

The results of recent studies which have shown large variations in density and hydraulic conductivity with depth in a backfilled slurry wall (Haug et al, 1990). In addition, the effective stress associated with the conditions near the bottom of a trench may reduce the effects of physical and chemical deterioration (Haug et al, 1990; Yang and Barbour, 1991; Quigley, 1992). Since much of the previous work on soil chemical degradation has been conducted under high effective stress environments (suitable for liners under a landfill), these results may not be equally applicable to the upper portion of SB slurry walls (Haug et al 1993).

In summary, as long as the contaminants are in dilute aqueous form, with a dielectric constant similar to water, pH between 5-8 and electrolytes at normal concentrations found in groundwater, a soil/bentonite (SB) slurry wall should not be adversely affected by the chemicals at the Site. As a result, the slurry wall design and durability testing shall be focussed upon determining the suitability of BW trenching slurry and SB backfill for the Site slurry wall. The testing program will be designed to investigate the potential for adverse chemical effects in the upper portions of the saturated zone (at the water table where the slurry wall would be under the least effective stress and subjected to the highest chemical strengths).

Bentonite is a generic name given to the clay mineral sodium-montmorillonite. This mineral has a "plate-like" structure with high activity and thus, has excellent swelling characteristics when hydrated by water. Bentonite is a naturally occurring mineral mined in the States of Wyoming, South Dakota and Montana and is a readily available commercial product. The quality of all bentonites can vary widely, depending on the thickness and conformity of the beds, milling procedures and quality control (Reschke and Haug, 1991). Conventional bentonite such as Premium Gel from American Colloid will be used in the testing program. "Contaminant resistant polymerized bentonites" will not be used in this program as the

existing literature suggests that they provide no advantage over conventional bentonite. In addition, it is noted that the polymer may degrade over long-term applications. (Haug and Boltd-Leppin, 1993)

The results and analysis of the overburden borehole investigation will be used to determine if the native soils will provide a minimum of 25 percent fine materials (silts and clays) (and 10 to 20 percent coarse) and thus be appropriate for use in the backfill mixture with bentonite. The soil which will be utilized in the laboratory testing program for backfill materials will be comprised of native soil obtained from borehole samples located along the alignment of the slurry wall and appropriate imported backfill consisting of fines passing the No. 200 standard sieve and coarse materials, as required.

If additional soils are required to complete the slurry wall a borrow area(s) or source location(s) where the fines or coarse content exceeds the 25 or 10 to 20 percent criteria will be identified.

Other backfill materials (i.e. soil-attapulgate) would be evaluated if the BW/SB designs are identified to be adversely affected by Site contamination.

#### 4.7.2.7 Task SWDP7 - Slurry Wall Laboratory Testing Program

##### Overview

The testing program to be used will be comprised of three phases. Phase I will be concerned with testing the bentonite in bentonite-water mixtures such as would be used to keep the trench open prior to backfilling. These tests will determine the potential reactivity of the bentonite-water slurry mixtures when contacted with clean tap water and Site groundwater. Bentonite-water slurries which show adverse reactions such as flocculation, with these permeants, will be removed from subsequent testing phases. In addition, the bentonite will be tested for the presence of polymers (as required). Rationale for determining adverse reactions is discussed in the Phase I discussion provided below.

Phase II of the testing program will determine a design backfill mixture of SB which provides the lowest hydraulic conductivity when permeated by clean tap water.

Finally, Phase III testing will determine the durability of the selected design mixtures when permeated by tap water and Site groundwater over an extended length of time (90 to 180 days). The purpose of the Phase III testing is to determine the long term effects of the various permeants on the hydraulic conductivity of the selected design mixture(s). The use of contaminated groundwater from the Site as a permeant in the durability testing will allow an estimation to be formulated as to the potential for degradation to the slurry wall backfill (due to contact with contaminated groundwater).

Table 4.1 presents a summary of the design compositional ranges for BW trenching slurries and SB backfill mixes. These design ranges are based upon experience and are consistent with a review of the available scientific literature.

Each of the Phase I, II and III testing programs are discussed below.

A. Phase I Testing Program

The Phase I testing program is designed to provide an accelerated method of screening the test mixtures. This phase will show initial gross incompatibilities and thus, these mixtures may then be removed from subsequent costly and time consuming analyses. The bentonite shall be mixed into three slurries with bentonite concentrations of 3.5, 5.0, and 6.5 percent by weight. These samples represent the trenching slurries which would be used to maintain trench stability. Two sets of slurries shall be formulated with each of these mixes as follows:

1. hydrated with clean tap water; and
2. hydrated with Site groundwater.

Slurry samples shall be prepared in accordance with API-13 and shall be tested for the following using API RP 13B methods:

1. viscosity;
2. apparent viscosity;
3. plastic viscosity;
4. yield point;
5. filtrate loss;
6. filter cake thickness; and
7. density.

In addition, the bentonite will be tested for the presence of polymers in accordance with Reschke, 1990. Table 4.2 provides a summary of the test samples for the bentonite trenching slurries.

All slurry samples will be visually inspected for flocculation and other adverse physical attributes. The criteria which will be used to identify slurry mixtures which exhibit adverse effects to permeating fluids will generally be of a qualitative nature. Those mixtures will be visually inspected in a graduated cylinder by experienced laboratory technicians. Adverse effects such as flocculation and lamination are easily verified by visual inspection. Photographic documentation of the test design mixes for the Phase I testing program will provide part of the visual evaluation of the sample mixtures. In addition, all mixtures identified in the Phase I program will have specific gravity measurements recorded upon completion of thorough mixing and hydration. Adverse effects will be gauged by comparing the results of baseline condition (samples mixed with water) to the results of samples mixed with the Site groundwater. Mixtures exhibiting adverse effects are expected to show dramatic decreases in the specific gravity of the mixture. Adverse reactions will be characterized visually and will be quantified as any mixture which has a specific gravity decrease of greater than 5 percent when compared to the baseline mixtures.

The Phase I testing program will also include "cracking" tests on the clays. The cracking tests will include the mixing (i.e. hydrating) of

the clays in an open pan with the addition of water and Site groundwater. Samples will be hydrated enough to produce a four to six-inch slump. The samples will be visually inspected for cracking and shrinkage. Photographic documentation of the tests will provide part of the visual evaluation. These tests will provide a qualitative measure of the effects of water and Site groundwater on the filter cake which would form during the actual construction activity.

B. Phase II Testing Program

The Phase II testing program is concerned with designing a suitable backfill mixture providing the required hydraulic conductivity. The grain size distribution of the SB backfill soils shall be determined (ASTM D422) and fines passing the Standard U.S. Sieve #200 shall be added (if required) such that the soil has minimum of 25 percent passing the #200 U.S. Standard Sieve and 10 percent gravel (3/4" to 3")..

The soil samples for SB testing will then be blended with the bentonite slurries containing 3.5, 5 and 6.5 percent bentonite by dry weight. In addition, baseline hydraulic conductivity testing (remolded) will be conducted on the backfill soils (without clay particle or remolded fines addition to the native soils) to determine the hydraulic conductivity of the native soils which shall be used to complete the construction of the slurry wall.

The SB mixtures will be mixed with water to achieve a required slump of four to six inches (ASTM C143).

The fully hydrated, thoroughly mixed samples will then be subjected to hydraulic conductivity testing using consolidometer permeameters permeated by tap water as discussed below in Paragraph D (below).

The samples that produce hydraulic conductivities of  $\leq 1.0 \times 10^{-7}$  cm/s will then become potential test specimens for the Phase III testing program. A summary of the test specimens is provided in Table 4.3.

The results of the Phase II testing will be utilized to determine if additional dry bentonite will be required to be added to the bentonite slurry/soil (eg. SB) mixture. If necessary, additional tests will be conducted with supplemental dry bentonite being added to the mixture.

A selected set of samples that provide the required hydraulic conductivity will be further evaluated in Phase III of the testing program for durability.

C. Phase III Testing Program

The design mix(es) selected during the Phase II program shall be tested for long term durability to determine the effects on hydraulic conductivity of the mixes when permeated by tap water and Site groundwater over extended lengths of time (90 to 180 days). The purpose of the durability testing is to provide the necessary information to allow an estimation of the potential adverse effects which contaminated Site groundwater may have on the completed slurry wall.

The principal objective of this testing is to ensure that the slurry wall will perform adequately for the duration of its intended service life. The two most important areas to evaluate are hydraulic conductivity and volume change. It is important that these slurry walls have sufficiently low hydraulic conductivity and maintain this level for their required service life. However, slurry walls and other barrier materials can also undergo change in volume due to chemical reactions which may create voids, resulting in a more permeable secondary structure. This secondary structure results in a secondary permeability which is difficult to measure in laboratory permeability tests. Measuring volume change of test specimens during hydraulic conductivity testing is one method of assessing the potential magnitude of any secondary permeability.

Each sample shall be placed in a consolidometer perimeter as specified in D. below. Samples shall be prepared using both tap water and Site groundwater for hydrating agents and prepared in duplicate for each of

two permeating liquids. All sample hydraulic conductivities will be monitored over an extended length of time (90 to 180 days) and graphs of hydraulic conductivity versus time shall be prepared. In addition, pore volumes, which are a measure of dimensionless time, will be monitored in the laboratory by measuring column percolate. It is expected that the extended length of time proposed for this program will allow more pore volumes to percolate through the samples than what is currently being done in the industry. This will provide a better estimate as to the long term durability of a constructed slurry wall. The suitability of the backfill materials will be determined from this phase. In addition, samples of the backfill may be tested for mineralogical analysis (XRD) before and after the Phase III tests.

Table 4.4 provides a summary of the number of samples which must be analyzed for each design mixture test material.

D. Generalized Laboratory Protocol

1. conduct a grain size analysis on averaged (with depth) backfill soils;
2. as applicable add the appropriate amount of fines (i.e. minus #200 sieve size) to bring the fines content up to the specified 25 percent minimum; in addition, add appropriate gravel to bring gravel percentage to 10% (3/4" to 3");
3. conduct a grain size analysis on the materials;
4. measure out the appropriate percentage of bentonite on a dry weight basis to form the required bentonite slurries;
5. add hydrating fluid (i.e. tap water or Site groundwater to the bentonite) to form slurries;
6. thoroughly mix and agitate the bentonite slurry;
7. allow the slurry to hydrate for 24 hours;
8. thoroughly mix and agitate the bentonite slurry;
9. add the bentonite slurry to the soil backfill material;
10. thoroughly mix and agitate the backfill sample;
11. conduct slump test;
12. add hydrating fluid as required to achieve the required slump (i.e. 4 to 6 inches);
13. remove samples for density and grain size analysis;

14. thoroughly mix and agitate the backfill sample;
15. allow the sample to hydrate for 24 hours;
16. thoroughly mix and agitate the backfill sample;
17. place backfill sample in consolidometer permeameter with porous stones on top and bottom.

The sample volume will be on the order of 1325 cubic centimeters with the following dimensions:

1. height 3 inches
2. diameter 6 inches

18. rod and vibrate sample to remove air voids;
19. employ back pressure (bottom up) saturation techniques;
20. use a normal stress of approximately 2.5 psi to 5.0 psi (to be determined after backfill density is measured (approximately 100 to 120 pcf) and based upon effective stresses expected at the water table depth;
21. employ gradient of less than 30;
22. using de-aired tap water and groundwater, permeate the sample using falling head procedures;
23. measure volume change during permeation (one-dimensional volume change);
24. continuously measure flow in and flow out of the sample;
25. continue Phase II tests for a minimum of one week, until a minimum of 2 pore volumes have passed through the sample and until partial stable hydraulic conductivity values have been reached (K versus time is constant and flow in to the sample equals flow out);
26. remove samples for density and water content analysis.

The following testing procedure is recommended for the Phase III testing. These procedures can also be used as an alternative for the Phase II tests.

1. conduct a chemical and mineralogical (XRD) analysis on the backfill material (as required),
2. consolidate backfill samples in a consolidometer permeameter as described previously;

3. extract the consolidate sample;
4. wrap consolidated sample in teflon tape;
5. place in latex membrane;
6. place sample in flexible wall permeameter;
7. conduct test using effective confining stress of 2.5 psi (or as determined suitable);
8. use hydraulic gradients of less than 30;
9. use initial vacuum and continuous back pressure saturation (30 psi);
10. continuously measure K and volume change with flow up through sample.
11. use de-aired tap water and groundwater to permeate the samples using constant head testing procedures (chemistry of permeants to be determined in advance);
12. sample effluent under backpressure (30 psi) in quantities of 5 mL for immediate analysis (effluent should be collected in chemically resistant burettes);
13. test effluent for organic and inorganic chemistry, in comparison with the inflow fluid to evaluate dissolution of minerals in the sample, adsorption/desorption of ions and other physiochemical processes.
14. continue test for Phase III testing until a minimum of 3 to 5 pore volumes have been passed through the sample and/or full stable hydraulic conductivity has been reached (K versus time is constant, flow in equals flow out, and outflow chemistry is stable).
15. remove samples for density, water content, XRD and elemental chemical analysis (as required).

This alternative "2-stage" test for the Phase III testing may be applicable. This type of procedure could be utilized dependent upon the laboratories apparatus availability. Alternatives to these procedure, if substantively different, will be discussed with U.S. EPA (prior to their implementation).

E. Discussion

1. Trenching Slurry

The purpose of the trenching slurry is to maintain the vertical trench walls without any other means of support during the excavation phase. The fluid consistency of the trenching slurry is defined in terms of viscosity, gelation and density. The viscosity of the trenching slurry will define the ease with which the slurry may be pumped through a piping network from a mixing plant into the trench as well as defining the rate at which suspended solids in the slurry will settle to the bottom of the trench.

Gelation is defined as the stiffening action that occurs in the trenching slurry after motion ceases. Gelation is important because it will maintain suspended solids in the vertical column and will reduce settling of solids.

The density of the trenching slurry is important for two reasons:

1. if the density of the trenching slurry is uniform from the surface to the key of the trench, then the slurry may be defined as having good gelation. Adequate gelation will reduce the settling of solids into the key of the trench which is the most critical area of the trench, and
2. the density of the trenching slurry must be low enough to allow the designed backfill to easily displace the trenching slurry.

The ideal trenching slurry would have the following properties:

1. low viscosity
  - to expedite pumping and backhoe production
2. high gelation
  - to maintain solids in suspension thus eliminating the need for cleaning of the keyway slot

3. high density
  - high enough to offset hydrostatic pressure and thus maintain trench stability.

The designed trenching slurry will compromise between these ideals and what may be achieved under field conditions.

The second primary factor which provides trench wall stability is the formation of a filter cake on the trench walls. The filter cake forms when water is squeezed out of the slurry through the trench walls. This in turn allows the hydrostatic force of the slurry to be more easily transferred to the walls of the trench.

Filter cake formation is dependent on the following:

1. clay type;
2. clay concentration;
3. water chemistry;
4. formation time;
5. quantity and type of chemical additives; and
6. hydrostatic pressure

The hydraulic conductivity of the filter cake will be on the order of  $10^{-7}$  to  $10^{-9}$  cm/s. Filtrate (water) loss from the trench will result in increasing the proportion of bentonite and solids in the trenching slurry. This is important because high filtrate loss will result in increased gelation, density and viscosity which in some cases may hinder construction of the slurry wall.

## 2. Backfill Design

The primary goal of the backfill material is to achieve a hydraulic conductivity on the order of  $1.0 \times 10^{-7}$  cm/sec, if possible. The hydraulic conductivity of the backfill material must not be adversely affected by the permeation of contaminated groundwater over extended lengths of time.

The ideal grain size distribution for use as a low permeability slurry wall backfill material is a well graded soil in the grain size range from silt and clay to fine sand. This is necessary to maintain the minimum porosity which must be filled by the bentonite clay. The backfill mix should have a minimum of 25 percent fines (particles passing U.S. Standard Sieve #200) and 10 to 20 percent gravel (3/4" to 3"). If the representative soil does not meet this specification, a source of suitable fines and gravel shall be located and added to the native soil to bring the fines/coarse content up to the 25/10 to 20 percent level prior to bentonite mixing.

#### 4.7.2.8 Task SWDP8 - SWDP Report

An SWDP report will be prepared for the review of the U.S. EPA that presents a summary and results of the SWDP program. The information generated during the SWDP will support the preliminary design.

### 4.8 GROUNDWATER MONITORING PROGRAM (GMP)

The groundwater monitoring program (GMP) is designed to detect changes in the chemical concentration of the groundwater at the Site prior to start-up of the groundwater extraction system. The groundwater monitoring program will include collection and field and laboratory analysis of samples from the monitoring wells presented on Figure 4.4. The GMP also includes the installation of five new monitoring well couplets (Figure 4.4). It should be noted that the GMP is to commence within six months of lodging of the Consent Decree.

The GMP will be comprised of the following Tasks:

- |            |                                |
|------------|--------------------------------|
| Task GMP1: | Site Inspection                |
| Task GMP2: | Procurement of Subcontractors  |
| Task GMP3: | Monitoring Well Reconnaissance |
| Task GMP4: | Monitoring Well Installation   |

Task GMP5:	Survey
Task GMP6:	Groundwater Sampling
Task GMP7:	Sample Analysis/Data Validation
Task GMP8:	Data Evaluation
Task GMP9:	GMP Report

#### 4.8.1 Task GMP1 - Site Inspection

A detailed Site inspection shall be conducted to evaluate and assess the present conditions of the Site and to confirm the locations for the new monitoring wells. Access to drilling and sampling locations and sampling equipment needs will be reassessed during the Site inspection.

#### 4.8.2 Task GMP2 - Procurement of Subcontractors

Final procurement of subcontractors will occur after the GMP has been approved by U.S. EPA. It is expected that the following subcontractors will be required:

1. Driller - qualified environmental drilling firm;
2. Land Surveyor - licensed State of Michigan land surveyor; and
3. Chemical Analysis - qualified and approved laboratory.

All GMP protocols, regulations, procedural and guidance documents agreed upon between the Group and U.S. EPA will be applied to all subcontractors retained by the Engineer during the implementation of the GMP. The Engineer will manage and coordinate all field activities completed by subcontractors.

#### 4.8.3 Task GMP3 - Monitoring Well Reconnaissance

A monitoring well reconnaissance will be completed to determine the current condition of each existing RI monitoring well to be

utilized during the GMP. The locations of the existing monitoring wells are presented on Figure 4.4. The monitoring well reconnaissance may include the following sub-tasks:

- Task GMP3.1    Review of Stratigraphic Logs
- Task GMP3.2    Field Inspect Monitoring Wells
- Task GMP3.3    Measure Water Level
- Task GMP3.4    Sound Bottom of Wells
- Task GMP3.5    Check Well Recoveries
- Task GMP3.6    Summarize Monitoring Well Conditions

Based upon the information gained during the monitoring well reconnaissance, wells which are determined to be inoperable, broken or compromised (or otherwise not recommended for sampling) will be replaced (if deemed necessary) or deleted from the BGM (after approval by U.S. EPA).

All monitoring well reconnaissance activities shall be conducted in accordance with the SAP, QAPP and HASP.

#### 4.8.4 Task GMP4 - Monitoring Well Installation

Additional groundwater monitoring wells shall be installed at the locations presented on Figure 4.4 to supplement the existing monitoring wells identified on Figure 4.4. The new monitoring wells include the replacement of three existing monitoring well couplets (GH14 A,B, GH15 A,B and GH16 A,B) and two new monitoring well couplets as presented on Figure 4.4. Each couplet consists of two monitoring wells screened in the upper (0 to 10 feet below the water table) and lower (15 to 25 feet below the water table) portions of the upper sand aquifer, respectively. The installation will be completed as described in the following sub-tasks:

- Task GMP4.1:    Pilot Borings
- Task GMP4.2:    Monitoring Well Abandonment
- Task GMP4.3:    Monitoring Well Installation

## Task GMP4.4: Monitoring Well Development

### Task GMP4.1: Pilot Borings

Pilot borings will be completed at the monitoring well locations presented on Figure 4.4 to determine the stratigraphy and finalize the design of the monitoring wells in each couplet (i.e. screened interval, screen slot size and sand pack interval).

Pilot boreholes will be advanced by means of a drilling rig equipped with hollow stem augers (HSA). Continuous soil sampling (to provide a geologic record) will be conducted during the completion of all boreholes. Geologic sampling intervals may be decreased (e.g. 5-foot intervals) during the drilling program. This determination will be dependent on the findings of the field drilling program as it proceeds.

All samples will be collected by means of a split spoon sampler (as described in ASTM D 1586) driven into the ground with a 140 lb hammer force falling 30 inches. The sampler will be driven into the bottom of the borehole 24 inches at a time and the number of hammer drops required to drive the sample through each 6-inch increment will be recorded. If the soil has the tendency to fall out of the split spoon sampler while being retrieved, a clean basket retainer will be used.

Following the collection of soil samples which provide the geologic record of the borehole, the split spoon sampler will be cleaned as follows:

- (a) clean off any gross contamination with a stiff brush;
- (b) wash and scrub with low phosphate detergent; and
- (c) rinse with distilled water.

The hollow stem augers and associated drilling equipment will be cleaned at the start and end of the project and between boreholes (as necessary) by high pressure steam cleaning. Steam cleaning will be conducted at the on-Site decontamination facility.

Following retrieval of the individual split-spoon samples, the soil samples will be immediately screened with a PID (e.g. HNu) as the split spoon is opened. A log of organic vapor readings shall be maintained for each borehole. Samples will then be carefully examined by an experienced Geologist/Engineer for color, soil type, stratigraphy, banding, moisture, odor, signs of contamination and any other identifying feature. The top two inches or any part of the upper sample which appears to be soil carried or fallen from the upper levels of the boreholes will be immediately discarded. The sample will then be photographed (if required) and placed in sample jars to provide a geologic record of the borehole.

The geologic samples will be sequentially numbered as the borehole advances. The location and number of the geologic samples shall be recorded on the borehole log.

At the completion of each borehole the geologic samples shall be placed in sample boxes and moved to the on-Site support trailers.

#### Task GMP4.2: Monitoring Well Abandonment

Three (3) existing monitoring well couplets (GH14A,B, GH15A,B and GH16A,B) will be abandoned in a manner consistent with the Michigan Department of Public Health procedures and protocols. Each monitoring well will be abandoned consistent with the following procedure:

- 1) inject pure bentonite grout into the screen interval using a tremie pipe starting from the bottom up;
- 2) continue backfilling the riser pipe with bentonite grout using a tremie pipe;
- 3) the top of the grout shall be to a level above the groundwater table but does not need to extend to the ground surface;
- 4) excavate original concrete protective collar and excavate around riser pipe;
- 5) cutoff riser pipe at a minimum depth of 2 feet below ground surface; and

- 6) fill the remaining unfilled portion of borehole with concrete.

Solid waste and well abandonment displacement water will be containerized for disposal on the landfill surface as discussed in Section A.7.0 of the SAP.

Well closure logs shall be completed for each abandoned well and submitted to the Michigan Department of Public Health, Division of Water Supply.

#### Task GMP4.3: Monitoring Well Installation

A total of five monitoring well couplets (ten monitoring wells) will be installed at the locations presented on Figure 4.4. This includes the replacement of GH14, 15 and 16A,B as well as the installation of two new couplets.

Following the completion of the pilot borehole the hole will be completed as an upper sand aquifer B horizon well (15 to 25 feet below the water table). An upper sand aquifer A horizon well (0 to 10 feet below the water table) will be installed adjacent to the B horizon monitoring well.

All monitoring wells installed at the Site will consist of two-inch diameter stainless steel riser pipe with a five-foot long stainless steel well screen. The screens will be packed with a clean quartz sand where the natural formation does not collapse. The sand pack will be extended to two feet above the top of the screen. A two-foot bentonite pellet plug will be placed on the sand pack. The remainder of the boring annulus will be backfilled with a cement bentonite grout. A lockable protective cap will be installed at the ground surface. Each monitoring well will be provided with knockdown protection. The details of each monitoring well installation will be outlined on a monitoring well construction log. The monitoring wells will be constructed as presented on Figure 4.5.

#### Task GMP4.4: Monitoring Well Development

The new monitoring wells will be developed prior to sampling in accordance with the following protocols.

- 1) Water levels in all wells will be measured to  $\pm 0.01$  foot prior to development;
- 2) All wells will be developed to a silt-free condition, if possible, following installation, by one of the following techniques:
  - a) pumping using a stainless steel bladder pump with teflon bladder and discharge tubing and polyethylene air supply line attached to a nylon rope;
  - b) peristaltic pump with teflon discharge tubing. For development the small length of silicon within the pump will not be replaced;
  - c) submersible pump;
  - d) positive displacement pump,
  - e) air lifting (via nitrogen), or
  - f) bailers.

Discharge tubing, if used, will be dedicated to each well. New polyethylene air tubing and nylon rope, where applicable, will be used at each well location;

- 3) During development, sediment within the well will be placed into suspension by agitation of the discharge tubing (or bailer);
- 4) After each well volume is removed, a sample will be collected and analyzed for pH, temperature and conductivity. Development will continue until three consecutive and consistent readings of pH, temperature and conductivity are obtained. Readings will be considered consistent if all three conductivity values are within ten percent of the average value and all pH values are within  $\pm 1$  pH unit of the average value over the last three volumes. In the event that these field measurements are not consistent, well development will

continue to a silt free condition, if possible, or until a maximum of ten well volumes have been removed;

- 5) In wells where discharge is insufficient to conduct the development protocol described in 4) above, the well will be pumped to dryness on three consecutive working days. Wells which are developed to dryness will not be subject to the above stabilization criteria. The three consecutive days can be split to allow for a break for the weekend;
- 6) Well development records shall be maintained as each well is developed; and
- 7) All development water will be handled in accordance with the protocols specified in Section A.7.0 as presented in Appendix A.

#### 4.8.5 Task GMP5 - Survey

A well location/elevation survey will be completed to determine the accurate location and measuring point elevation of each new monitoring well. This survey is required to tie in the additional wells to the existing wells and surrounding topography. The survey will be completed in a manner such that the information can be easily assimilated into electronically based plans.

#### 4.8.6 Task GMP6 - Groundwater Sampling

##### 1. Sampling Frequency

After the Consent Decree has been lodged and prior to U.S. EPA approval for start-up of the groundwater extraction system, the monitoring wells identified on Figure 4.4 shall be sampled on a semi-annual basis to monitor the plume.

## 2. Analysis

Consistent with the SOW, the GMP shall include both field and laboratory analysis of samples from the monitoring wells.

Field analysis shall include at a minimum, groundwater elevation, pH, temperature, and specific conductivity. Prior to collecting samples for laboratory analysis, all monitoring wells will be purged consistent with the procedures outlined in Appendix A.

Groundwater samples shall be collected consistent with the protocols established in Appendix A. Laboratory analysis will be completed for the compounds identified in Table 4.5.

If additional information indicates that the groundwater sampling program is not monitoring the entire contaminant plume or that there are additional chemical parameters of concern to U.S. EPA, then U.S. EPA may require that additional groundwater monitoring wells or sampling parameters be added to the regular sampling program.

All sampling activities and analyses will be completed in conformance with the SAP, QAPP and HASP.

### 4.8.7 Task GMP7 - Sample Analysis/Data Validation

The Engineer shall retain a laboratory to complete all chemical analyses. All chemical analyses shall be completed in accordance with the QAPP.

Sample collection information will be recorded on chain of custody forms prior to delivery to the laboratory. Upon receipt at the laboratory, the project Quality Assurance Officer (QAO) will confirm the delivery was received and that the laboratory understood the request for analysis. The Engineer's QAO will monitor the sample analysis during the project.

Detailed information regarding quality assurance protocols and procedures is provided in the SAP and QAPP.

The project QAO will perform an independent data validation in accordance with the current U.S. EPA standards and guidelines. Based on the QA/QC results, the project QAO will accept, qualify or reject the results of the analysis.

All staff involved in the implementation and application of the data validation process will be qualified and have a minimum of one year experience in the data validation process.

#### 4.8.8 Task GMP8 - Data Evaluation

After data from all sources are received and validated by the QAO, a thorough evaluation of the data will be undertaken by the project data evaluation staff. The evaluation will include the following activities:

1. developing groundwater contours;
2. determining plume geometry; and
3. reviewing the nature and extent of groundwater contamination in comparison to previous sampling data in order to detect the changes in chemical concentrations.

The data will be evaluated utilizing sound hydrogeologic and scientific principles by the project hydrogeologic personnel.

#### 4.8.9 Task GMP9 - GMP Report

At the completion of all sampling, analysis, data validation and evaluation, the Engineer shall develop a report which will discuss the changes in the chemical concentrations of the groundwater over time.

The GMP report will be submitted to U.S. EPA for review and approval.

#### 4.9 EXTRACTION WELL DESIGN PROGRAM (EWDP)

The purpose of the Extraction Well Design Program (EWDP) is to provide data to evaluate and design the extraction and treatment well systems and to determine the optimum pumping rates to extract the plume located outside the source containment system. The proposed groundwater extraction well locations are presented on Figure 4.6. More specifically, the test extraction well will serve to provide data for the following:

1. calculation of aquifer characteristics to refine extraction well spacing and yields;
2. determination of zones of capture; and
3. determination of the degree of interconnection between the shallow, intermediate and bedrock aquifers.

The EWDP will be completed as the following tasks:

Task EWDP1:	Preparation
Task EWDP2:	Test Extraction Well Installation
Task EWDP3:	Extraction Well Development
Task EWDP4:	Pumping Test
Task EWDP5:	Pump Test Analysis
Task EWDP6:	Modeling
Task EWDP7:	EWDP Report

It should also be noted that high hydraulic gradients across a backfilled slurry wall can cause hydrofracturing across the wall (Spooner, 1985). The installation of the extraction wells close to the slurry wall may cause hydrofracturing if the hydraulic pressure across the wall exceeds 1 psi per foot of depth, and the horizontal pressure acting across the

wall are greater than the vertical pressure. For this reason, it is important that the extraction wells be placed sufficiently back from the slurry wall to prevent this problem. This requirement will be evaluated during the pre-design.

#### 4.9.1 Task EWDP1 - Preparation

Preparation for the EWDP will include procurement of a driller and surveyor and the reconnaissance of the test extraction well location.

#### 4.9.2 Task EWDP2 - Test Extraction Well Installation

A six-inch diameter test extraction well will be installed between GH02A,B,C and GH03A,B,C as presented on Figure 4.4. This test extraction well will serve to provide necessary information for the extraction well system design. The test extraction well has been located in an area in which it may be utilized as an extraction well during the RA.

A pilot boring shall be completed as described in Section 4.8. Soil samples for grain size analysis will be collected over the proposed screen interval. The grain size data will be utilized to design the test extraction well screen slot size or the necessity for a proper gradation of the sand pack.

The test extraction well will be six inches in diameter and screened over approximately one half of the saturated thickness. The total depth of the well is approximately 25 feet.

The construction details for the test extraction well are schematically illustrated on Figure 4.7.

#### 4.9.3 Task EWDP3 - Extraction Well Development

The extraction well will be developed by jetting or pumping and surging the well until the water is essentially free of sediment. A well development log will be maintained. Development water will be discharged as described in the SAP. The information generated during well development activities will be utilized to determine the pump flow rates for the pumping tests discussed in Task EWDP4.

#### 4.9.4 Task EWDP4 - Pumping Test

A pumping test consisting of a step-drawdown test and a constant-rate aquifer test of 72 hours duration will be conducted on the test extraction well identified in Task EWDP2. A complete round of water level measurements will be taken for each well in the pumping test monitoring network at least 24 hours prior to commencement of the pumping test. The pumping test monitoring network will include the following wells:

- |               |           |
|---------------|-----------|
| 1. GH02,A,B,C | 7. GH34B  |
| 2. GH03A,B,C  | 8. GH39A  |
| 3. GH04B      | 9. GH40B  |
| 4. GH07A      | 10. GH43B |
| 5. GH25A      | 11. GH44A |
| 6. GH33B      | 12. GH45A |

A subset of the above identified monitoring wells will be identified as "core" wells for the pump test. The core wells are the monitoring wells that are in close proximity to the pumping well. The water levels in the core wells will be measured using data loggers. The other wells will be designated as "skeleton" wells. The skeleton wells are generally further from the pumped well and are monitored using electronic water levels. The water level monitoring schedule is presented in Table 4.6.

The step-drawdown test will consist of pumping the test well at a minimum of three different flow rates for a one hour period.

Pumping will be performed at increasing flow rates. The flow rates to be used and the duration of each step will be determined in the field. The initial flow rate will be based upon the known hydrogeologic properties of the unconfined aquifer and upon the results of the test extraction well development (in consultation with U.S. EPA). Upon completion of the step test, an optimum flow rate for the constant-rate aquifer pumping test will be determined.

Prior to conducting the pumping test, the pump test well network will be monitored for an antecedent-trend period for a duration of at least 24 hours (or as required). During the antecedent-trend period, hydraulic head will be measured at core monitoring wells using a data logger and twice daily using an electronic water level probe at the remaining skeleton wells. This information will be utilized to determine any natural hydraulic head trends within the aquifer. Additionally, barometric pressure will be monitored to determine the response of the aquifer to changes in atmospheric pressure. Hydrographs will be prepared of hydraulic head versus time and hydraulic head versus barometric pressure for each of the observation points such that the trend and rate of water level change can be determined, and compensated for, during the interpretation of pump test data.

The constant rate aquifer test will be conducted at a continuous pumping rate for a 72-hour duration. Water level measurements will be obtained in the pumping test well and pumping test monitoring wells using data loggers or an electronic water level tape. Water level measurements will also be recorded in a similar manner as the test proceeds. The pumping test monitoring network may be reduced depending on observed response in the monitoring wells during the pumping test.

At the end of the constant-rate test, the pump will be shut off and water levels will be measured until at least 90 percent recovery of the static water level is measured in the extraction and monitoring wells. The same monitoring frequencies identified in Table 4.6 will be utilized to monitor the pump test shut down.

Discharge of pump test water is discussed in the SAP.

#### 4.9.5 Task EWDP5 - Pump Test Analysis

The drawdown values will be used to determine the upper sand aquifer hydraulic parameters. The drawdown and recovery data will be reduced and analyzed by the methods by Theis (1935) and/or Cooper and Jacobs (1946), as appropriate. In addition, the analytical solution of Hantush and Jacob (1955) will be used to evaluate the data in order to determine the degree of hydraulic connection between the aquifers. Other solutions (such as Neuman, 1975) will be utilized on an as-required basis to ensure that the pump test data is properly evaluated.

The drawdown experienced by the observation wells will provide an estimate of the capture zone associated with the pumping rate.

#### 4.9.6 Task EWDP6 - Modeling

In order to determine optimum locations and pumping rates for the extraction well network and to minimize well interference associated with excessively large cones of influence, groundwater modeling may be performed. Computer modeling will be carried out using an appropriate groundwater modeling program such as the numerical, two-dimensional horizontal aquifer simulation Flowpath (Version 3.0) developed by Waterloo Hydrogeologic Software of Waterloo, Ontario.

The theoretical basis of Flowpath is the governing equation for two-dimensional, steady-state flow in heterogeneous, saturated, anisotropic, porous media (see Appendix E). A finite difference method is employed to solve the governing equation for two-dimensional, steady-state horizontal flow. Through this method, a rectangular grid is superimposed over the area of consideration of the groundwater system to discretize the system into grid cells that are small compared to the spatial extent of the

entire aquifer. Specifically, Flowpath uses a block-centered finite difference scheme.

Aquifer properties, namely: hydraulic conductivities, porosity, aquifer thickness and aquifer bottom elevation are defined for each block and can be varied from block to block. The flux induced by infiltration or exfiltration from surface water bodies is accounted for by adding a head-dependent flux to the source or sink term. The boundary conditions are specified for any type of boundary, namely, constant head node, no-flux and constant flux boundary.

Aquifer properties which will be used in the model will be estimated from information developed during the pumping test. The groundwater model will be calibrated by varying the hydraulic properties of the aquifer and comparing the results to the actual pumping program conducted as part of EWDP5.

#### 4.9.7 Task EWDP7 - Report

A report will be prepared for the review of U.S. EPA which presents the results of the EWPD. The information generated during the EWDP will support the preliminary design.

#### 4.10 GROUNDWATER TREATABILITY STUDIES

As stated in the SOW, extracted groundwater will be treated on Site prior to discharge to the wetlands, the Clinton River, or alternatively, the DWDS treatment plant. Groundwater to be treated will be generated from the source containment system and the groundwater extraction system. The groundwater treatment process, based on the groundwater quality data presented in the RI, is specified in the SOW to include the following steps: oil and water separation, metals removal (i.e. precipitation, clarification, and filtration), and organic chemical removal (aeration and carbon polishing) (as necessary) to meet the required cleanup

standards in the discharge water and air. The following provides an overview of the approach which has been conceptualized to conduct the treatability studies. Necessary revisions will be presented to U.S. EPA for review and approval if and as required.

#### 4.10.1 Introduction

The groundwater at the Site has been found to contain both volatile (VOC) and semi-volatile organic compounds (SVOC) . Some of these compounds include benzene, toluene, ethylbenzene, xylene, (BTEX) chlorinated solvents, polynuclear aromatic hydrocarbons (PAH), 4,4'-DDD, 4,4'-DDT, and Aroclor-1254.

The selection and design of the groundwater treatment process(es) will be based on existing groundwater quality data, the additional groundwater analytical data to be generated from the Groundwater Monitoring Program discussed in Section 4.8, and the detailed findings from the groundwater treatability study.

The conceptual groundwater treatment system under consideration is expected to contain the following unit operations:

- oil/water separation via dissolved air flotation;
- treatment for the inorganic constituents by using chemical precipitation;
- removal of any residual VOC via air stripping; and
- removal of residual SVOC and other organics in the groundwater by carbon adsorption.

The feasibility of incorporating a biological unit operation has been reviewed based on the results of past groundwater characterization data. Biological treatment is not considered to be technically feasible because the concentration of biodegradable organic compounds was shown to be too low to sustain microbial growth (Biological Oxygen Demand (BOD) is 2 to 13 mg/L). In addition, other organic constituents found at the Site, such as

4,4'-DDT, 4,4'-DDD and chlorinated solvents, are known to or may be resistant or inhibitory to biodegradation.

Chemical oxidation processes such as ultraviolet radiation (UV), ozone treatment, and UV in combination with hydrogen peroxide are potential options for removing organic compounds in groundwater. Since most of these oxidation processes are innovative emerging technologies and very vendor specific, their applicability for this Site will be further assessed once additional groundwater characterization data is obtained.

The need for a chemical precipitation operation will depend, in part, on whether metal removal is required. The Site groundwater is expected to contain both dissolved and suspended solids which typically deposit or precipitate onto groundwater treatment components such as air strippers and carbon adsorbers. This deposition and precipitation will adversely affect the performance of these treatment systems. Consequently, the additional groundwater characterization data and the groundwater treatability studies described below have been developed to determine both performance and operational design parameters for the groundwater treatment system.

Depending on the eventual discharge criteria for metals and other inorganic constituents, other specific chemical treatment processes may have to be considered. For example, sulfide precipitation can be applied to remove lead to low concentration, bisulfite can be used to reduce chromium, and activated alumina can be used to achieve very low arsenic concentration in the effluent. If ammonia removal is required, ion exchange would be considered and evaluated in the treatability study. The need for any of these processes will be determined based on the additional groundwater quality data to be generated from other tasks and clean-up criteria for the treated water. The treatability study work developed within this RD/RA Work Plan will only address oil/water separation and removal, chemical pretreatment and filtration, air stripping, and activated carbon treatment. Additional treatability studies and evaluations or modifications to the studies outlined may be required based upon information generated during the implementation of this program.

QA/QC procedures for the sampling and analytical component of the treatability studies will be in accordance with the SAP and QAPP.

#### 4.10.2 Treatability Study

##### 4.10.2.1 Scope of Work

The scope of the groundwater treatability studies will include bench-scale tests during the pre-design phase of the project which will be carried out at an off-Site research testing facility. The need for pilot-scale testing (either during the pre-design or actual remedy construction) will be determined based on the results of the laboratory tests. If it is determined that pilot-scale treatability tests are required during the remedy construction, a separate Groundwater Treatability Study Work Plan will be prepared for submittal with the pre-final design. These pilot tests will be designed to determine the effectiveness of the groundwater treatment steps on groundwater extracted from the actual groundwater extraction system (see Section 5.4).

Conceptualized laboratory- and pilot-scale tests which may comprise the treatability study include the following:

##### Laboratory-Scale Testing

- Test 1: laboratory-scale jar tests to evaluate solids precipitation resulting from pH adjustment;
- Test 2: laboratory-scale test to evaluate solids precipitation resulting from aeration and VOC removal by low air to water ratio aeration processes;
- Test 3: laboratory-scale jar tests to evaluate precipitation processes resulting from chemical addition;

- Test 4: green sand filtration tests to evaluate dissolved and suspended solids removal processes (if initial suspended solids are high, Test 5 will be used prior to Test 4);
- Test 5: multi-media filtration tests to evaluate solids removal processes;
- Test 6: isotherm batch tests to evaluate activated carbon processes; and
- Test 7: UV/H<sub>2</sub>O<sub>2</sub> lab test to evaluate chemical oxidation processes.

#### Pilot-Scale Testing

- Test 8: Pilot-scale test to evaluate and develop air stripping design parameters; and
- Test 9: Pilot-scale test to evaluate oil/water separation via dissolved air flotation.

#### 4.10.2.2 Site-Specific Parameter List

Prior to conducting the treatability studies, a round of groundwater samples will be collected from specified monitoring wells as described in Section 4.8. A Site-specific Parameter List (SSPL) will be developed based on the analytical results of these analyses and available data from the GMP (Section 4.8).

The SSPL will be used when evaluating treatment system performance during the treatability studies. Consequently, the SSPL will consist of volatile and semi-volatile organic compounds and heavy metals, (if determined to be present above the groundwater clean-up standard). Additional parameters to be added to the SSPL for the purpose of the treatability studies may include water quality items such as turbidity, total suspended solids (TSS), etc. which could adversely affect treatment performance for the targeted compounds or adversely affect operations.

#### 4.10.2.3 Data Management and Reporting

Treatability study data will be reviewed for precision, accuracy and completeness. If QA objectives are not met, appropriate corrective actions will be taken.

Data will be presented in tabular or graphical form where possible. Critical parameters for supplemental testing will be identified. Data collection efforts for pilot-scale work will allow statistical analysis to be performed.

#### 4.10.3 Laboratory-Scale Tests

Laboratory-scale (bench-scale) treatability evaluations will be conducted as the first step towards the evaluation of several treatment technologies. The objective of the laboratory-scale studies will be to determine which treatment technologies are appropriate for the treatment of the groundwater to be extracted at G & H Landfill Site.

A representative composite sample of sufficient volume of the groundwater extracted during the pumping test (Section 4.8) (in addition to groundwater collected from monitoring wells located along the alignment of the collection trench) will be collected and stored in multiple full amber clean glass bottles. These glass bottles will be properly capped, labeled with date of collection and sample location, and stored at 4°C until the bench-scale tests are conducted. Sufficient volume or bottles of water will be obtained such that each sample bottle will be used on a one-time only basis after opening. This representative groundwater sample will be used to conduct all tests targeted in the bench-scale treatability studies to ensure consistency in the results. The procedures for bench-scale tests consisting of pH adjustment, aeration and chemical precipitation are detailed in the Site-specific SAP.

#### 4.10.4 Pilot-Scale Tests

##### 4.10.4.1 Overview

Pilot-scale testing will be restricted to the assessment of the aeration/air stripping and oil/water separation and removal processes. Information to assess the suitability of the other processes (e.g. carbon treatment, filtration) to be implemented as part of the treatment program can reasonably be extrapolated from the laboratory/bench-scale tests.

##### 4.10.4.2 Aeration/Air Stripping Test

If the results of the laboratory aeration test prove to be successful, the tank aeration test will be conducted at a pilot scale. The final size and configuration of the pilot unit will be based on the results of the laboratory test and the additional data on groundwater characterization. If the results of the laboratory aeration test proved to be unsatisfactory, packed tower or shallow tray air stripping will be considered as an alternative technique. The selected treatment process will be tested at a pilot scale (10 gpm). The test will be used to determine key parameters such as optimum air to water ratio, percent removal efficiency, and solids formation.

Groundwater will be pumped from a feed tank to the pilot aeration unit. During the operation of the pilot test, influent and effluent samples will be collected daily and analyzed for the SSPL.

At the end of the pilot test run, the pilot unit will be shut down and inspected for signs of deposition, precipitation and biological growth. The rates of deposition, precipitation and biological growth will be determined by visual inspection. Samples of deposits which may have formed within the pilot unit may be collected for follow-up analysis for compounds such as calcium, iron and sulfate which may be present.

#### 4.10.4.3 Oil/Water Separation Test

Floating oil has been identified in several monitoring wells at the Site. The non aqueous phase liquids (NAPL) will be removed via an oil/water separator. Residual oil can be removed by a dissolved air flotation process. This process relies on the release of very small bubbles into the water which become attached to the oil droplets to be removed. The attachment of bubbles to the oil droplets dramatically reduces the density of the oil droplets resulting in an enhanced oil flotation. Chemical conditioning is often used to increase the effectiveness of the dissolved air flotation process. The effectiveness of this process can be affected by many factors such as air to solids ratio, suspended solids quantities and qualities, presence of surfactants, etc.

A pilot scale test will be conducted on Site using a 1 sq. ft. pilot-scale air flotation unit (K-S Model 1 from Komline-Sanderson or equivalent). Total petroleum hydrocarbons (TPH) and the SSPL will be analyzed in samples taken before and after the dissolved air flotation process to monitor test performance.

#### 4.11 EVALUATION OF DISCHARGE REQUIREMENTS

An evaluation of discharge requirements for the discharge of treated groundwater from the on-Site treatment system will be conducted to evaluate the various discharge options available for the Site. The discharge requirements for the Site may affect the requirements for water treatment and treatability study procedures.

The evaluation will include an assessment of discharge requirements to the DWSD treatment plant and will discuss discharge requirements under an NPDES discharge permit.

Discharge requirements for the DWSD treatment plant will be determined by contacting the DWSD which will identify the present

available capacity at the DWSD treatment plant. In addition, DWSD will identify acceptable pre-treatment water quality criteria for acceptance.

Discharge to the Clinton River under the substantive requirements of an NPDES discharge permit will require the completion of a technical evaluation of NPDES requirements. The MDNR will be contacted to obtain Clinton River discharge criteria under the NPDES program prior to conducting the treatability study and water treatment unit design work. An evaluation of the possible NPDES permit requirements will be presented in the 30 percent design.

#### 4.12 SOIL/SEDIMENT PCB SAMPLING PROGRAM (SSPS)

The Soil/Sediment PCB Sampling Program (SSPS) will be conducted to fully delineate the nature and extent of soil/sediments south of the oil collection trench which contain PCBs at a concentration of 1 ppm or greater. Figure 4.8 presents the areal limits of the PCB soil/sediment sampling area as specified in the SOW. The information developed during the SSPS program will be evaluated to identify the soil/sediments to be excavated and removed from the contaminated area and placed under the landfill cap (i.e. <500 ppm) or destroyed off Site (i.e. incineration) (>500 ppm). The SSPS program will be comprised of the following activities:

##### Tasks:

Task SSPS1:	Site Inspection
Task SSPS2:	Procurement of Subcontractors
Task SSPS3:	Soil Sample Collection - Round 1
Task SSPS4:	Soil Sample Collection - Round 2
Task SSPS5:	Sample Analysis/Validation
Task SSPS6:	Data Evaluation
Task SSPS7:	SSPS Report

#### 4.12.1 Task SSPS1 - Site Inspection

A detailed Site inspection within the limits of the area to be investigated for PCBs (Figure 4.8) shall be conducted to evaluate and assess the present conditions of this area of the Site and to confirm the locations for the soil/sediment sampling activities. Access to sampling locations and sampling equipment needs will be reassessed during the Site inspection.

#### 4.12.2 Task SSPS2 - Procurement of Subcontractors

Final procurement of subcontractors will occur after the RD/RA Work Plan has been approved by the U.S. EPA. It is expected that the only subcontractor required will be a qualified and approved chemical analysis laboratory. However, it should be noted that in the event a second round of soil sampling is required, a qualified environmental drilling company may be required to obtain soil or sediment samples at depth.

SSPS program protocols, regulations, procedural and guidance documents agreed upon between the Group and U.S. EPA will be applied to all subcontractors retained by the Engineer during the implementation of the SSPS program. The Engineer will manage and coordinate all field activities completed by subcontractors.

#### 4.12.3 Task SSPS3 - Soil/Sediment Sample Collection - Round 1

An initial round of soil/sediment samples will be collected to determine the extent of PCBs in the first 36 inches below ground surface (BGS). A total of approximately 36 soil/sediment locations will be sampled. The sample locations are presented on Figure 4.9. Surficial soils or sediments will be sampled at each sample location. Subsurface soil samples will be collected utilizing a hand driven split spoon sampler. The split spoon will be advanced and soil samples will be collected in 12-inch intervals BGS. A total of three subsurface soil samples will be collected at each location to a total depth of 36 inches.

A representative sample over each 12-inch interval (in addition to the surficial sample) will be placed in a sample jar and sequentially numbered as the borehole advances. All samples shall be shipped to the laboratory within 24 hours of sampling under Chain-of-Custody procedures and analyzed for TCL PCBs. The location and sample number of each sample shall be recorded in the borehole log. The need for additional sampling locations will be determined during the completion of field activities or during review of the data developed during this activity in consultation with U.S. EPA (see Task SSPS4 below).

#### 4.12.4 Task SSPS4 - Soil Sample Collection - Round 2

A second round of soil samples will be collected at the round 1 sampling locations where PCBs were determined to be at a concentration greater than 1 ppm at the interval of 24 to 36 inches BGS. The purpose of the round 2 soil sampling is to determine the extent of PCBs at a depth of greater than 36 inches that are at a concentration greater than 1 ppm.

Round 2 soil sampling will require the services of a qualified drilling company to perform boreholes to allow for the collection of split spoon samples at depths greater than 36 inches.

The maximum depths for the round 2 soil sampling will be determined based on field conditions and the round 1 sampling results. Sampling protocols for the collection of split spoon samples are outlined in the SAP (Appendix A).

A represent sample over each additional 12-inch interval (below the 36-inch depth) will be placed in a sample jar and sequentially numbered as the borehole advances. All samples shall be shipped to the laboratory within 24 hours of sampling under Chain-of-Custody procedures and analyzed for TCL PCBs. The location and sample number of each sample shall be recorded in the borehole log.

In addition, during the round 2 sampling, supplemental surficial soil samples may be collected at locations in between those identified on Figure 4.9 to provide additional horizontal control on PCB concentrations (if required).

#### 4.12.5 Task SSPS5 - Sample Analyses/Data Validation

The Engineer shall retain a laboratory to complete all chemical analyses. All laboratory chemical analyses shall be completed in accordance with protocols and procedures presented in the QAPP.

Samples will be recorded on chain of custody forms prior to delivery to the laboratory. Upon receipt at the laboratory, the project Quality Assurance Officer (QAO) will confirm the delivery was received and that the laboratory understood the request for analysis. The Engineer's QAO will monitor the sample analysis during the project.

Detailed information regarding quality assurance protocols and procedures is provided in the SAP and QAPP.

The project QAO will perform an independent data validation in accordance with the current U.S. EPA standards and guidelines. Based on the QA/QC results, the project QAO will accept, qualify or reject the results of the analysis. All staff involved in the implementation and application of the data validation process will be qualified and have a minimum of one year experience in the data validation process.

#### 4.12.6 Task SSPS6 - Data Evaluation

After data from all sources are received and validated by the QAO, a thorough evaluation of the data will be undertaken by the project data evaluation staff.

Results of the field investigation will be compiled, validated and evaluated to provide a logical analysis of the vertical and horizontal extent of PCB contamination in the designated area. The testing will determine and assess the Site areas and volume of soils/sediments containing between 1 and 500 ppm PCBs and the volume containing greater than 500 ppm.

#### 4.12.7 Task SSPS7 - SSPS Report

An SSPS Report will be prepared which presents a summary of the SSPS program. The report will define the procedures used and the results that were obtained. The information generated from the SSPS will support the preliminary design.

The report will include all sample locations and results, including laboratory reports, and an evaluation of the extent of the PCB contamination.

#### 4.13 SURFICIAL WATER AND SEDIMENT MONITORING PROGRAM (SWSMP)

The surficial water and sediment monitoring program (SWSMP) is designed to monitor chemical concentrations in the surface waters and sediments and to detect any adverse conditions caused by the Site in the Rochester-Utica Recreational Area, the wetlands, the Clinton-Kalamazoo Canal and the Clinton River. Surface water and sediment sampling will continue until the PCB excavation program is completed and the source containment system and cap are installed.

The surface water and sediment sampling locations are presented on Figure 4.10.

The SWSMP will be comprised of the following Tasks:

Task SWSMP1:	Site Inspection
Task SWSMP2:	Procurement of Subcontractors
Task SWSMP3:	Survey
Task SWSMP4:	Surface Water and Sediment Sampling
Task SWSMP5:	Sample Analysis/Data Validation
Task SWSMP6:	Data Evaluation
Task SWSMP7:	SWSMP Report

#### 4.13.1 Task SWSMP1 - Site Inspection

A detailed Site inspection shall be conducted to evaluate and assess the present conditions of the Site and to confirm the surface water and sediment sampling locations. Access to sampling locations and sampling equipment needs will be reassessed during the Site inspection.

#### 4.13.2 Task SWSMP2 - Procurement of Subcontractors

Final procurement of subcontractors will occur after the RD/RA Work Plan has been approved by U.S. EPA. It is expected that the following subcontractors will be required:

1. Land Surveyor - licensed State of Michigan land surveyor; and
2. Chemical Analysis - qualified and approved laboratory.

It should be noted that the procurement of the subcontractors for this task will be performed in conjunction with the procurement of the subcontractors for GMP.

All SWSMP protocols, regulations, procedural and guidance documents agreed upon between the Group and U.S. EPA will be applied to all subcontractors retained by the Engineer during the

implementation of the SWSMP. The Engineer will manage and coordinate all field activities completed by subcontractors.

#### 4.13.3 Task SWSMP3 - Survey

A survey will be completed (as required) to determine the accurate location of each surficial water and sediment sampling activity. The survey will be completed in a manner such that the information can be easily assimilated into electronically based plans. All sampling locations will be accurately marked to allow them to be easily found during future sampling activities.

#### 4.13.4 Task SWSMP4 - Surface Water and Sediment Sampling

##### 1. Sampling Frequency

The surface water and sediment samples shall be collected in the locations designated on Figure 4.10 on an annual basis until the source containment system and cap are installed and the PCB excavation program is completed.

##### 2. Analysis

The surface water and sediment samples shall be analyzed for the compounds listed in Table 4.5 as well as for TCL PCBs.

Surface water and sediment sampling and equipment cleaning will be performed consistent with the protocols established in the SAP.

#### 4.13.5 Task SWSMP5 - Sample Analyses/Data Validation

The Engineer shall retain a laboratory to complete all chemical analyses. All chemical analyses shall be completed in accordance with the QAPP.

Sample collection information will be recorded on chain of custody forms prior to delivery to the laboratory. Upon receipt at the laboratory, the project Quality Assurance Officer (QAO) will confirm the delivery was received and that the laboratory understood the request for analysis. The Engineer's QAO will monitor the sample analysis during the project.

Detailed information regarding quality assurance protocols and procedures is provided in the SAP and QAPP.

The project QAO will perform an independent data validation in accordance with the current U.S. EPA standards and guidelines. Based on the QA/QC results, the project QAO will accept, qualify or reject the results of the analysis.

All staff involved in the implementation and application of the data validation process will be qualified and have a minimum of one year experience in the data validation process.

#### 4.13.6 Task SWSMP6 - Data Evaluation

After data from all sources are received and validated by the QAO, a thorough evaluation of the data will be undertaken by the project data evaluation staff. The evaluation will include for each sampling date, a review of the nature and extent of surface water and sediment contamination in comparison to previous sampling data in order to detect any changes in chemical concentrations.

The data will be evaluated utilizing sound and scientific principles by the project data evaluation personnel.

#### 4.13.7 Task SWSMP7 - SWSMP Report

At the completion of all sampling, analysis, data validation and evaluation, the Engineer shall develop a report which will discuss any temporal changes in the chemical concentrations of the surface water and sediments.

The report will be submitted to U.S. EPA for review and approval.

#### 4.14 AUTOMOBILE DISPOSAL YARD DATA EVALUATION

The Automobile Disposal Yard (Junkyard) soil sampling and analysis program was performed by CRA to determine if there are any contaminant sources in the unsaturated soils and any remaining surface debris at the Junkyard. The Junkyard location is presented on Figure 4.11.

Consistent with the SOW, an Automobile Disposal Yard Soil Sampling and Analysis Work Plan (Work Plan) was submitted to the U.S. EPA. The approved Work Plan outlined soil sampling locations and protocols. As discussed in the Work Plan, a total of 23 boreholes were drilled to the top of the upper sand aquifer groundwater table during the period from October 26, 1992 to October 30, 1992.

The approximate borehole locations are presented on Figure 4.12. Soil samples for chemical analysis were collected from the top two feet and bottom two feet of each borehole. A third sample was collected from a central depth from each borehole. Each soil sample was analyzed for Target Compound List (TCL) VOC, TCL PCB and Target Analyte List (TAL) metals.

The results of the soil sampling program will be used to determine the remedy requirement for the Junkyard area. Remedial options for the Junkyard include no action, or removal and/or capping of the surface soils and debris.

#### 4.15 MUNICIPAL WATER CONNECTION PROGRAM

Consistent with the requirements of the SOW, the Group shall coordinate the connection of municipal water to the residences and businesses identified on Figure 1.10. This activity will include the abandonment of the private water wells in accordance with the protocols and procedures identified for well abandonment in Section 4.8 (consistent with the Michigan Department of Health guidelines).

The construction of municipal water connections is to be completed within twelve months of the lodging of the Consent Decree (see Section 8.0). Coordination of activities is required with several parties for the municipal water connections. These parties include the individual property owners, Shelby Township Department of Public Works - Water and Sewer, and the Michigan Department of Public Health.

A tasked approach will be utilized to complete the municipal water connections. These tasks are identified as follows:

- Task 1: Identification of Properties
- Task 2: Ryan Road Watermain Extension
- Task 3: Service Connections

##### Task 1: Identification of Properties

The properties that are not currently connected to the municipal water supply (see Figure 1.10) will be contacted by the Group to determine which owners request to be connected to the municipal supply. Table 4.7 identifies the owners, and owners' addresses (as provided by Shelby Township) of the properties presented on Figure 1.10. Letters requesting

access for municipal water connection and abandonment of the existing private supply wells will subsequently be forwarded to the identified owners. Access issues are discussed in Section 4.1.

### Task 2: Ryan Road Watermain Extension

In order to provide municipal water connections to the properties located further south along Ryan Road, the existing watermain, which presently terminates just north of the abandoned Conrail Railway easement, must be extended southerly along Ryan Road (as these properties are not currently fronted by the municipal watermain). This requires coordination with the Shelby Township Department of Public Works - Water and Sewer.

Complete engineering plans have to be submitted, approved and ultimately certified by the Michigan Department of Public Health for a construction permit. Once a permit is obtained, bids will be solicited and a contract awarded by Shelby Township for construction of the watermain. Shelby Township has indicated that this entire procedure may require up to six months to complete.

### Task 3: Service Connections

The connections for municipal water supply require a service connection to the municipal watermain which fronts each property within the roadway right-of-way.

The service connection will be completed in two stages. The first stage involves tapping the watermain and installing a water meter and service line from the watermain to the front property line. The second stage involves the installation of a copper service line from the property line to the house or commercial building. The second stage requires the Group to arrange the service connection activities for the individual property supply systems. This requires the contracting of a general construction contractor by the Group to complete the activities.

The final stage is implemented by identifying to the Shelby Township Department of Works - Water and Sewer the properties that require a municipal connection. The Township will subsequently charge a tapping fee to install a service line from the watermain to the property line.

## 5.0 REMEDIAL DESIGN ACTIVITIES

The Remedial Design (RD) activities which are to be completed are discussed in the following subsections:

- 5.1 General Overview
- 5.2 Permitting Requirements
- 5.3 Preliminary Design (30 Percent)
- 5.4 Pre-Final Design (95 Percent)
- 5.5 Final Design (100 Percent)

### 5.1 GENERAL OVERVIEW

RD activities generally consist of preparing engineering drawings, specifications, bid documents and supporting calculations for the various components of the RA. The design of each component of the RA also reflects the requirements imposed by all applicable local, State and Federal laws, regulations and permits (substantive requirements). The design process is sometimes an iterative process where a preliminary design is developed and reviewed by appropriate regulatory Agencies before permit requirements, which affect the final design, can be incorporated into the final design.

The major components of the RD are specified in the SOW as follows:

#### **"A. Design Plans and Specifications**

*Settling Defendants shall develop clear and comprehensive design plans and specifications which include, but are not limited to, the following:*

1. *Discussion of the design strategy and the design basis, including:*

- a. *Compliance with all applicable and relevant and appropriate environmental and public health standards; and*
  - b. *Minimization of adverse environmental and public impacts.*
2. *Discussion of the technical factors of importance including:*
  - a. *Use of currently accepted environmental control measures and technology;*
  - b. *The constructability of the design; and*
  - c. *Use of currently acceptable construction practices and techniques.*
3. *Descriptions of assumptions made and detailed justification of these assumptions.*
4. *Discussion of the possible sources of error, including references in the Operation and Maintenance Plan to possible operation and maintenance problems.*
5. *Detailed drawings of the proposed design including:*
  - a. *Qualitative flow sheets; and*
  - b. *Quantitative flow sheets.*
6. *Tables listing equipment and specifications.*
7. *Tables giving material and energy balances.*

8. *Appendices including:*

- a. *Sample calculations (one example presented and explained clearly for significant or unique design calculations);*
- b. *Derivation of equations essential to understanding the report;*
- c. *Groundwater treatability study and pump test work plans; and*
- d. *Results of laboratory and field tests.*

B. *Cost Estimate*

*Settling Defendants shall develop cost estimates to construct and implement the remedial action. The cost estimate developed in the FS shall be refined to reflect the more detailed/accurate design plans and specifications being developed. The cost estimate shall include both capital and, in the Operation and Maintenance Plan, the operation and maintenance costs. Should EPA determine that it must assume the RD/RA responsibility, Settling Defendants, upon request, shall provide the most recent cost estimates to EPA.*

C. *Project Schedule*

*Upon EPA approval of the RD/RA Work Plan, Settling Defendants shall develop an expedited Project Schedule for construction and implementation of the remedial action which identifies the dates for initiation and completion of all critical path tasks. An Initial Project Schedule shall be submitted simultaneously with the Prefinal Design Document submission and the Final Project Schedule with the Final Design Document. The Final Project Schedule is subject to review and approval by EPA, in consultation with MDNR.*

D. Construction Quality Assurance Objectives

*Settling Defendants shall identify and document the objectives and framework for the development of a construction quality assurance program including, but not limited to, the following: responsibility and authority; personnel qualifications; inspection activities; sampling requirements; and documentation.*

E. Health and Safety Plan

*Settling Defendants shall develop a Health and Safety (H&S) Plan to address the activities to be performed at the Site to implement the remedial action. The H&S Plan shall be submitted to EPA and MDNR for review.*

F. Operation and Maintenance Plan

*Settling Defendants shall prepare an Operation and Maintenance Plan to provide for the long-term maintenance of the remedial action. The plan shall be composed of the following elements:*

1. *Description of normal operation and maintenance (O&M):*
  - a. *Description of tasks for operation;*
  - b. *Description of tasks for maintenance;*
  - c. *Description of prescribed treatment or operation conditions; and*
  - d. *Schedule showing frequency of each O&M task.*
2. *Description of potential operating problems:*
  - a. *Description and analysis of potential operation problems;*
  - b. *Sources of information regarding problems; and*
  - c. *Common and/or anticipated remedies.*

3. *Description of routine monitoring and laboratory testing:*

- a. *Description of monitoring tasks;*
- b. *Description of required laboratory tests and their interpretation;*
- c. *Required data collection, Quality Assurance Project Plan (QAPP);*
- d. *Schedule of monitoring frequency and date, if appropriate, when monitoring may cease; and*
- e. *Description of triggering mechanisms for groundwater/surface water monitoring results.*

4. *Description of alternate O&M:*

- a. *Should systems fail, alternate procedures to prevent releases or threatened releases to protect public health and the environment; and*
- b. *Analysis of vulnerability and additional resource requirements should a failure occur.*

5. *Corrective Action:*

- a. *Description of corrective action to be implemented in the event that groundwater Cleanup Standards are exceeded in the leading edge of the groundwater contaminant plume or NPDES criteria for discharges to surface waters or DWSD pretreatment criteria, if applicable, are exceeded;*
- b. *Description of corrective action to be implemented in the event that the cap has sustained any form of damage, including, but not limited to, cracking, penetration, and erosion;*
- c. *Description of corrective action to be implemented in the event that air stripper and/or landfill gas emission levels are exceeded; and*

- d. Schedule for implementing these corrective actions.*
- 6. Safety plan:*
  - a. Description of standard safety practices for site personnel, including, without limitation, precautions and necessary safety equipment; and*
  - b. Safety tasks required in event of systems failure.*
- 7. Description of equipment:*
  - a. Equipment identification;*
  - b. Installation of monitoring components;*
  - c. Maintenance of Site equipment; and*
  - d. Replacement schedule for equipment and installed components.*
- 8. Records and reporting mechanisms required:*
  - a. Operating logs;*
  - b. Laboratory records;*
  - c. Records for operating costs upon takeover;*
  - d. Mechanism for reporting emergencies;*
  - e. Personnel and maintenance records; and*
  - f. Monthly/annual reports to EPA and MDNR.*

*A draft Operation and Maintenance Plan shall be submitted simultaneously with the Final Design Document and the Final Operation and Maintenance Plan shall be submitted upon completion of construction." (SOW, pages 23-27).*

The SOW requires the following documents in support of the design:

- i) preliminary design (30 percent complete);*

- ii) pre-final design (95 percent complete); and
- iii) final design (100 percent complete).

These documents will be submitted as specified in the SOW (as presented in Sections 6.0 and 8.0). Review of submittals by U.S. EPA and dispute resolution will be governed by the relevant sections of the Consent Decree.

## 5.2 PERMITTING REQUIREMENTS

Pursuant to § 121(e)(1) of CERCLA, 42 U.S.C. § 9621(e)(1), all permits or approvals necessary under Federal, State and local laws for off-Site work, including transport and/or disposal of waste materials removed from the Site, will be obtained by submitting timely applications and requests for any such permits and approvals (if required).

During the preliminary design phase, each component of the remedy will be evaluated to determine which permit programs are potentially applicable. This will be accomplished through discussion with local, State and Federal Agencies. At this time, it is envisioned that the major permit programs to be considered are compliance with the substantive requirements for off-Site transportation and disposal of PCB contaminated soils.

The design requirements imposed by the applicable permit programs will be incorporated in the pre-final and final design submissions.

## 5.3 PRELIMINARY DESIGN (30 PERCENT)

The preliminary or 30 percent design report consisting of construction plans and technical specifications for all aspects of the selected remedy will be developed and submitted to U.S. EPA for review and approval. The preliminary design report will include verification of existing conditions and the results of pre-design investigations and evaluation (see

Section 4), and will reflect the design effort at 30 percent completion with calculations that reflect the same percentage of completion as the designs they support. Supporting data and documentation will be provided with the design documents defining the functional aspects of the remedy. As well, the preliminary design report will address all technical requirements of the project so that these aspects may be reviewed to confirm that the final design will be consistent with the SOW and Applicable or Relevant and Appropriate Requirements (ARARs) and will provide an operable and usable RA. At the 30 percent design stage, an assessment of permitting requirements will be made. This will include the identification of:

- i) construction/operating permits potentially required;
- ii) the permitting authority;
- iii) regulations governing applications, exemption and variances;
- iv) information required by each permit application; and
- v) time required by the permitting agency to process the application.

This information will be used to develop a program to assess the impact of the various permit programs on the design and to develop and submit the required applications.

At a minimum, the preliminary design submittal will include:

- i) documentation of Site boundaries and topography (including Site cross-sections), and locations of utilities;
- ii) discussion of utility and Site access requirements necessary to implement the RA, including an evaluation of the Detroit Water and Sewer Department (DWSD) easements;
- iii) results of the landfill gas evaluation and landfill cap material evaluation;
- iv) results of the wetlands delineation and preliminary mitigation requirements;

- v) results of the evaluation of the source containment options;
- vi) results of the slurry wall design program;
- vii) results of sampling and analysis of monitoring wells;
- viii) results of the groundwater pumping tests conducted during the EWDP and groundwater treatability study;
- ix) results of the groundwater treatability study and an evaluation of the effectiveness of the proposed treatment process, including a review of permitting requirements;
- x) preliminary design of the source containment collection drain, extraction wells and extracted groundwater transfer system, including pumphouses, electrical, mechanical and control requirements, forcemains and pump systems;
- xi) preliminary groundwater treatment system design based on the results of the groundwater treatability study, including component sizing and operation principles, and an assessment of the proposed treatment systems compliance with ARARs;
- xii) an evaluation of air emissions on-Site (including landfill gas vents and the groundwater treatment system);
- xiii) proposed design contours for the final Site cover including typical cross-sections reflecting the results of the topographical survey of the Site, material and vegetation specification for the Site cover, erosion control, and gas vents; and
- xiv) preliminary plans and specifications, conceptual aspects of the design and preliminary construction drawings reflecting the design effort at 30 percent completion, as well as an assessment of conformance with ARARs and performance standards.

It should be noted that the results of the pre-design studies and evaluations in conjunction with the 30 percent design will allow the potential for the optimization of certain remedy components (i.e. the construction of a fully encapsulating slurry wall may result in cost advantages associated with the extraction and treatment portion of the containment system).

Proposed changes to the remedy that may result through the pre-design and 30 percent design phase of the remedy would be proposed to U.S. EPA for consideration and approval. Any changes to the remedial components will be subject to the provisions of the CD and approval by U.S. EPA.

#### 5.4 PRE-FINAL DESIGN (95 PERCENT)

A pre-final design report reflecting the 95 percent completion stage will be submitted for review and approval by the U.S. EPA. The pre-final design will have addressed all comments generated from the review of the preliminary design and will clearly show any modifications of the design resulting from incorporation of these comments. The U.S. EPA may require an intermediate design review at 60 percent completion. If required, the intermediate design submittal will include the same elements as the pre-final design.

The pre-final design will include, as a minimum, the following:

- i) possible sources of error and references to potential problems and how potential problems may be resolved;
- ii) details and operation procedures of all components of the groundwater extraction and collection systems;
- iii) details and operation of all components of the extracted groundwater treatment system and confirmation of the treatment systems compliance with air emission and effluent discharge criteria;
- iv) landfill cover design;

- v) Site security fence design;
- vi) construction drawings and technical specifications suitable for bid purposes;
- vii) construction schedule for implementation of the RA;
- viii) assessment of conformance with ARARs, performance standards and permitting requirements; and
- ix) draft Groundwater Treatability Study Work Plan (if required).

The 95 percent design submittal will include:

- 1. Design Plans and Specifications;
- 2. Draft Operation and Maintenance Plan (OMP);
- 3. Initial Capital and Operation and Maintenance Cost Estimate;
- 4. Draft Construction and Operation Schedule;
- 5. Draft Quality Assurance Project Plan (QAPP); and
- 6. Draft Health and Safety Plan (HASP).

The Remedial Design Plans and Specifications shall include, at a minimum:

- 1. discussion of design strategy and the design basis;
- 2. discussion of relevant technical factors;
- 3. description and justification of assumptions made;
- 4. discussion of possible sources of error;
- 5. detailed drawings of proposed design;
- 6. equipment specifications;
- 7. material and energy balances; and
- 8. appendices including sample calculations, derivations, and results.

The Operation and Maintenance Plan (OMP) will be developed to ensure the safe and effective operation of the remedy. The elements of the OMP will include discussion of the following items:

- 1. health and safety plan;
- 2. normal operation and maintenance;
- 3. potential operating problems;

4. routine monitoring and testing;
5. corrective actions;
6. long-term monitoring and maintenance;
7. alternative operation and maintenance;
8. equipment description;
9. required records and reporting mechanisms; and
10. Post-Construction Groundwater Monitoring Plan.

The generic Operation and Maintenance Plans developed during the remedial design will be updated with specifics supplied by vendors for various components of the remedy when the remedial construction is completed.

A cost estimate for the remedy construction, operation and maintenance will be developed. This cost estimate will include costs associated with compliance monitoring as well as routine O&M and construction tasks.

#### Construction and Operation Schedule

A schedule of construction activities and anticipated groundwater extraction/treatment system startup and operation will be included with the 95 percent design submittal. This schedule will address major construction milestones, inspection activities, sampling to be performed prior to system startup, and extraction/treatment operation activities. Routine sampling for O&M purposes to be performed during extraction/treatment system operation will be scheduled according to the OMP. Compliance monitoring sampling will be performed in accordance with the Post-Construction Monitoring Plan.

A Compliance Monitoring QAPP for RA activities will be developed to ensure that all sampling and analytical activities are properly controlled and documented. The QAPP will be developed based upon U.S. EPA guidance and in accordance with the Consent Decree. The QAPP will include:

1. title page and statement of purpose;
2. project description;
3. project organization and responsibility;
4. sampling procedures and objectives;
5. sampling custody and document control;
6. calibration procedures and frequency;
7. analytical procedures, data reduction, validation, assessment and reporting;
8. internal QC checks and frequency;
9. performance and system audits and frequency;
10. preventative maintenance procedures and frequency;
11. method-specific procedures for assessing data precision, accuracy and completeness;
12. corrective actions; and
13. QA reports.

A Construction Health and Safety Plan (HASP) will be developed and designed to protect on-Site personnel and area residents from physical, chemical and other hazards posed during implementation of the RA. The HASP will address the following items:

1. general requirements;
2. personnel;
3. levels of protection;
4. safety work practices and safeguards;
5. medical surveillance;
6. personnel and environmental air monitoring;
7. personal protective equipment;
8. personal hygiene;
9. decontamination, personal and equipment;
10. Site work zones;
11. contaminant migration control;
12. contingency and emergency planning; and
13. logs reports and recordkeeping.

The HASP shall be prepared following U.S. EPA guidance and OSHA requirements as outlined in 29 CFR 1910.120.

#### 5.5 FINAL DESIGN (100 PERCENT)

The final design report containing design plans and specifications at 100 percent completion will be submitted to U.S. EPA for review and approval. This submittal will clearly address all comments from U.S. EPA's review of the pre-final design. The final design will include, as a minimum, the following:

- i) complete plans and specifications for both construction and bid purposes;
- ii) complete design analyses, including design calculations;
- iii) final construction schedule;
- iv) construction cost estimate; and
- v) assessment of conformance with ARARs, performance standards and permitting requirements.

The final design will reflect a level of effort such that the technical requirements of the RA selected for the Site have been addressed, and outlined such that it may be reviewed to determine substantial compliance with applicable requirements of the Consent Decree.

The 100 percent design submittal will include:

- 1. Final Design Plans and Specifications;
- 2. Final Construction Cost Estimate;
- 3. Final Operation and Maintenance Plan;
- 4. Final Quality Assurance Project Plans (QAPP);
- 5. Final project schedule;
- 6. Final Health and Safety Plan (HASP);
- 7. Final groundwater extraction rates; and
- 8. Final Groundwater Treatability Work Plan (if required).

The quality of the design documents will be such that they could be included in a bid package to invite contractors to submit bids for the construction project.

## 6.0 REMEDIAL ACTION ACTIVITIES

Remedial action activities involve all aspects of implementing the remedy at the Site. This involves Contractor selection, remedial construction, operation and maintenance, long-term monitoring and testing to ensure systems are operating effectively.

### 6.1 CONSTRUCTION QUALITY ASSURANCE PROGRAM PLAN

Following approval of the final design report, the Engineer will submit a Construction Quality Assurance (CQA) Program Plan. The CQA Program Plan will cover the construction (Task 3) of the final remedy. The CQA Program Plan will be a document which describes the Site-specific components of the groundwater extraction/treatment systems and landfill systems. The purpose is to insure that the systems will meet all design criteria, plans, and specifications. The CQA Program Plan will address several elements briefly summarized as follows.

#### Responsibility and Authority

The CQA Program Plan will fully describe the responsibility and authority of all organizations (e.g. technical consultants, construction firms) and key personnel involved in the construction of the remedial action. The CQA Program Plan will also identify a CQA officer and the necessary supporting inspection staff.

#### Construction Quality Assurance Personnel Qualifications

The qualifications of the CQA officer and supporting inspection personnel will be presented in the CQA Program Plan to demonstrate that they possess the training and experience necessary to fulfill their identified responsibilities.

## Inspection Activities

The observations and tests that will be used to monitor the construction and/or installation of the components of the remedial action will be summarized in the CQA Program Plan. The plan will include the scope and frequency of each type of inspection. Inspections will verify compliance with applicable or relevant and appropriate requirements and include, but not be limited to, air quality and emissions monitoring records and waste disposal records (e.g. RCRA transportation manifests). The inspection will also ensure compliance with all health and safety procedures. In addition to oversight inspections, the Group will conduct the following activities:

### 1. Preconstruction Inspection and Meeting

The Group will conduct a preconstruction inspection and meeting with representatives of U.S. EPA to:

- a. Review methods for documenting and reporting inspection data;
- b. Review methods for distributing and storing documents and reports;
- c. Review work area security and safety protocol;
- d. Discuss any appropriate modifications of the construction quality assurance plan to ensure that Site-specific considerations are addressed; and
- e. Conduct a facility walk-around to verify that the design criteria, plans, and specifications are understood and to review material and equipment storage locations.

The preconstruction inspection and meeting shall be documented by a designated person and minutes shall be transmitted to all parties.

## 2. Prefinal Inspection

Upon preliminary project completion, a prefinal inspection will be conducted. The prefinal inspection will consist of a walk-through inspection of the entire project at the Site. The inspection is to determine whether the project is complete and consistent with the contract documents and the U.S. EPA-approved remedial action(s). Any outstanding construction items discovered during the inspection will be identified and noted. Additionally, treatment equipment will be operationally tested. The Group will certify that the equipment has performed to meet the purpose and intent of the specifications. Re-testing will be completed where deficiencies are revealed. The prefinal inspection report will outline the outstanding construction items, actions required to resolve items, completion date for these items, and the data for the final inspection.

## 3. Final Inspection

Upon completion of any outstanding construction items, a final inspection will be completed. The final inspection will consist of a walk-through inspection of the entire project at the Site. The prefinal inspection report will be used as a checklist with the final inspection focusing on the outstanding construction items identified in the prefinal inspection. Confirmation that outstanding items have been resolved will be provided.

## Sampling Requirements

The CQA Program Plan will present sampling activities, sample size, sample locations, frequency of testing, acceptance and rejection criteria, and plans for correcting problems as addressed in the project specifications.

## Documentation

Reporting requirements for CQA activities will be described in detail in the CQA Program Plan. This will include such items as daily summary reports, inspection data sheets, problem identification and corrective measure reports, design acceptance reports, and final documentation. Provisions for the final storage of all records will be presented in the CQA Program Plan.

### 6.2 REMEDIAL CONSTRUCTION

The final remedy will be constructed and operated in accordance with the approved CQA Program Plan. A construction documentation report including daily summary reports, schedule of data submissions, design acceptance reports, photo documentation and record drawings will be submitted to summarize construction procedures. Progress reports will be prepared summarizing results of performance monitoring of the systems and other components of the final remedy. The construction documentation report will also include inspection data sheets, corrective actions summaries and final documentation for the RA.

At this time, it is envisioned that a separate contract will be established to complete the final remedy. The contract will be established for the construction of the landfill cap, source containment system, groundwater extraction/collection/treatment system and fence.

Contract and bid documents will be provided to pre-qualified contractors. A remedial contractor will be selected from the bids received.

The selected contractor will carry out the work in accordance with the approved design and CQA and under the supervision of a qualified engineer.

### 6.3 OPERATION AND MAINTENANCE

Operation and maintenance activities will be conducted in accordance with the approved Operation and Maintenance Plan (OMP). The major activities will involve the operation and maintenance of the source containment system, groundwater extraction/treatment systems and the landfill cap. The OMP will include a discussion of long-term groundwater monitoring programs to assess groundwater quality and groundwater treatment effectiveness.

An OMP will be submitted with the pre-final (95 percent) design package. This OMP will include descriptions of the normal operation and maintenance procedures to be followed for each system, the frequency of routine operation and management tasks, a description of potential problems and their possible remedies, a description of routine monitoring procedures and a schedule of routine monitoring activities. The OMP will also include an analysis of alternative procedures to be followed in the case of partial or total system failure. This section will describe potential vulnerability to anticipated natural or man-made disasters and procedures to be used to limit hazards to workers or the general public in the case of system failure. Additionally, the OMP will include health and safety requirements, description of equipment, records maintenance procedures and reporting requirements.

The OMP will include corrective actions to be taken in the case of anticipated problems with system operation or in the case of the failure of a system to perform as expected. A schedule for detection of potential problems and initiation of corrective action will be included.

A contractor or individual will be selected to carry out operation and maintenance activities.

#### 6.4 MONITORING AND TESTING

Long-term monitoring and testing will be conducted to monitor the effectiveness of each component of the remedy. Monitoring of groundwater quality and treatment effectiveness will be conducted. Specific monitoring and testing requirements will be presented as part of the OMP.

Monitoring will include the collection and analysis of groundwater samples from monitoring wells and all extraction wells. The monitoring system will assess the amount of contaminant reduction throughout the plume and ensure that the groundwater recovery system is capturing the plume and preventing the migration of contaminants from the recovery area. After the required clean-up levels have been achieved, groundwater sampling will be conducted quarterly for 24 months for verification.

After discontinuing operation of the groundwater extraction system, post-shutdown groundwater monitoring will be conducted. Monitoring will continue for thirty (30) years to demonstrate that the Cleanup Standards have been continuously satisfied.

Air emission monitoring of treatment systems will be conducted to assure that toxics criteria are met in accordance with the Clean Air Act and Michigan Act 348. Treatment systems include the groundwater treatment system and the cap gas-venting system.

#### 6.5 DECOMMISSIONING

Decommissioning of the source containment, groundwater extraction and treatment systems would occur using a phased approach after the requirements of the SOW have been obtained. The first phase of decommissioning would involve shutting the systems off and maintaining them in an operational state while continuing to monitor. The second phase of decommissioning would involve removal of salvageable components of the systems from the Site.

## 7.0 REPORTS AND DOCUMENTATION

### 7.1 MONTHLY PROGRESS REPORTS

Monthly progress reports will be provided to U.S. EPA as required by the Consent Decree and will include the following major items:

1. describe the actions which have been taken toward achieving compliance with the Consent Decree during the previous month, and attach copies of appropriate supporting documentation such as invoices, contract documents and photographs;
2. include all results of sampling and tests and all other data received by the Group during the course of the work which has passed quality assurance and quality control procedures;
3. include all plans and procedures completed under the RD/RA Work Plan during the previous month;
4. described all actions, data and plans which are scheduled for the next month and provide other information relating to the progress of construction; and
5. include information regarding percentage of completion, unresolved delays encountered or anticipated that may affect the future schedule for implementation of the Scope of Work or RD/RA Work Plan, and a description of efforts made to mitigate those delays or anticipated delays.

### 7.2 DRAFT AND FINAL TASK PLANS AND REPORTS

Upon U.S. EPA approval of the required RD and RD/RA Work Plans, the Engineer will continue implementation of the final remedy at the Site. The implementation of the final remedy includes the generation of additional plans and reports which are listed below:

Plans:

Project Plans:

Final RD and RD/RA Work Plans (including Final Health and Safety Plan, Quality Assurance Program Plan, Sampling and Analysis Plan Schedule for Completion of Tasks).

Remedial Design Plans:

Design Plans and Specifications (including Preliminary, Pre-Final and Final submittals).

Draft and Final Operation and Maintenance Plans.

Initial and Final Cost Estimates.

Draft and Final Construction and Operation Schedule.

Draft and Final Quality Assurance Project Plan.

Final Remedy Construction Plans:

Construction Quality Assurance (CQA) Program Plan.

Reports:

Groundwater Monitoring Report.

Surface Water and Sediment Monitoring Report.

Pre-Final Inspection Report.

Draft and Final Construction Completion Report.

Draft and Final Completion of Final Remedy Report.

Notification of Completion of Construction Report.

Final Construction Report.

### 7.3 PRE-DESIGN TREATABILITY STUDY REPORT

The results of the pre-design studies and evaluations will be provided with the 30 percent design submittal. It should be noted that preliminary groundwater treatability studies will be completed as outlined in Section 4.10. The necessity of completing additional groundwater treatability studies will be ascertained after completion of the preliminary 30 percent design. The additional treatability studies would be completed after the extraction system has been constructed. This will allow pilot tests to be conducted on the actual groundwater to be treated.

## 8.0 COMMUNITY RELATIONS

A community relations program will be implemented by the U.S. EPA. Support will be provided for community relations activities. This support may include, but is not necessarily limited to, preparation of information to be distributed to the public and attendance at public meetings held to inform the public of the progress of the final remedy at the Site. All community relations support provided to the U.S. EPA will be consistent with the guidelines published by the U.S. EPA in the "Guidance for Implementing the Superfund Program" and "Community Relations in Superfund - A Handbook".

## 9.0 SCHEDULE

The Consent Decree was lodged on September 10, 1992. The draft RD Work Plan was submitted to U.S. EPA on November 9, 1992, 60 days after lodging of the Consent Decree. A revised draft RD Work Plan was submitted to U.S. EPA on January 29, 1993, 45 days after U.S. EPA comments on the draft RD Work Plan. The final RD Work Plan was submitted to U.S. EPA on April 16, 1993 and was subsequently approved on April 22, 1993. Figure 9.1 presents a schedule for the activities keyed to the lodging of the Consent Decree. Figure 9.1 includes scheduling for the Groundwater Monitoring Program and the connections of residences and businesses to the municipal water supply (consistent with the SOW).

The RD/RA Work Plan and contingent pre-design/design submittals are dependent on the entry of the Consent Decree. The Consent Decree was entered June 30, 1993. A preliminary schedule for the pre-design activities and 30 percent, 95 percent and 100 percent design are presented on Figure 9.2. Remedial action scheduling will be developed during the RD phase of the project as the scope of the construction activities is defined.

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**TABLE 4.1**  
**COMPARISON OF DESIGN MIXES**

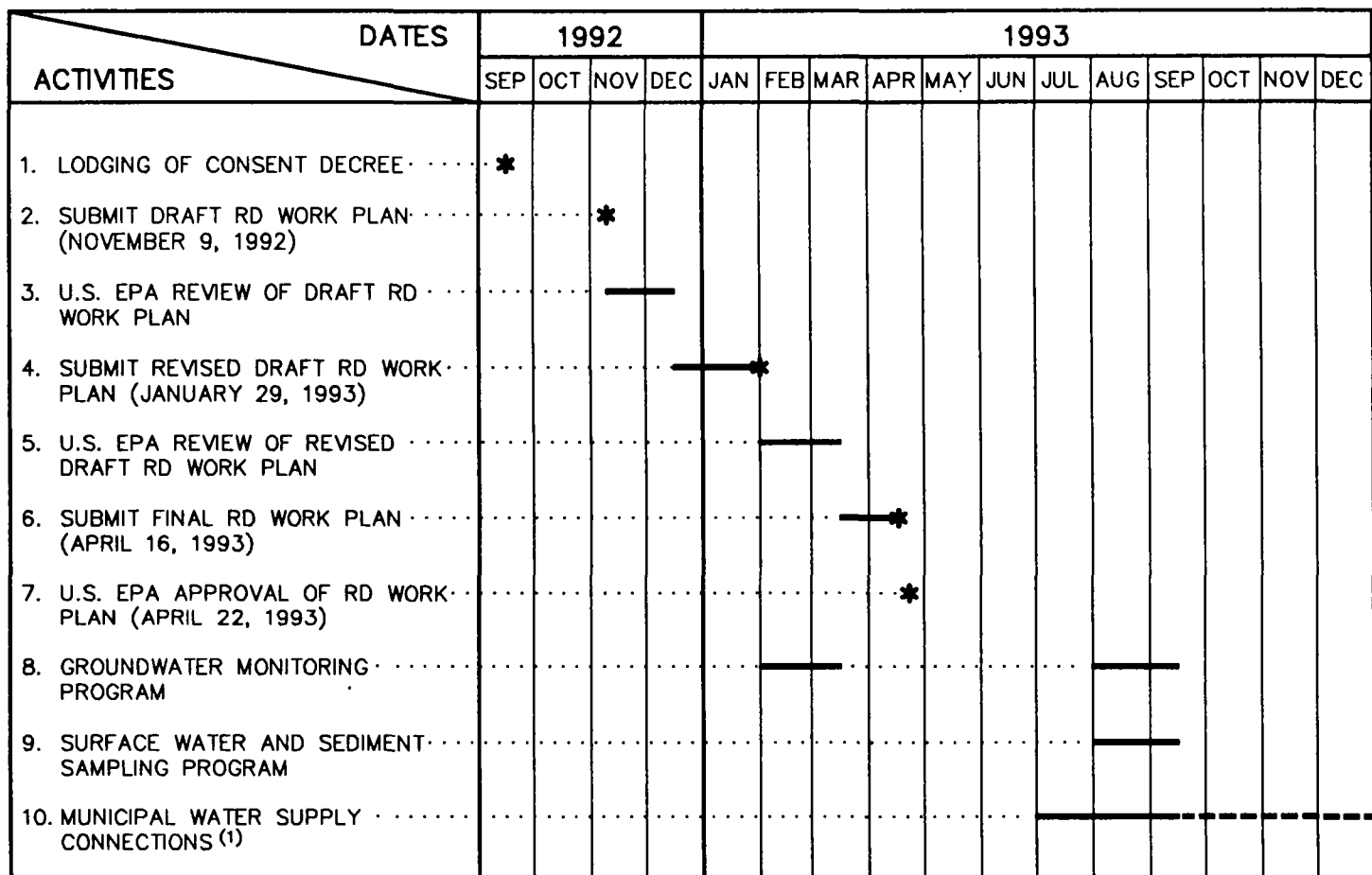
- |    |                                       |  |
|----|---------------------------------------|--|
| 1. | Trenching Slurry<br>(Bentonite-Water) | <ul style="list-style-type: none"> <li>- clean tap water (<math>6.5 &lt; \text{pH} &lt; 10</math>)</li> <li>- water-bentonite (Na montmorillonite)</li> <li>- 3.5% to 6.5% bentonite</li> <li>- <math>1,050 \text{ kg/m}^3</math> (density) (1.01 to 1.24 specific gravity)</li> <li>- minimum 40 Marsh funnel seconds viscosity (15 to 20 centipoises)</li> <li>- shear or flash mixing</li> <li>- 35 Marsh full seconds gelation</li> <li>- 10 to 25 <math>\text{cm}^3</math>/30 minutes filtrate loss at 100 psi</li> </ul> |
| 2. | SB Backfill                           | <ul style="list-style-type: none"> <li>- water-soil-bentonite</li> <li>- 0.5% to 3.0% bentonite</li> <li>- minimum <math>1,300 \text{ kg/m}^3</math> (density)</li> <li>- minimum 25% fines (i.e. less than 0.074 mm)</li> <li>- minimum 10% gravel (3/4" to 3")</li> <li>- slump: 4 to 6 inches</li> <li>- <math>K \leq 1 \times 10^{-7} \text{ cm/s}</math></li> <li>- use Na montmorillonite</li> <li>- mixed by dozer in prepared trench</li> </ul>  |

**TABLE 4.3**  
**PHASE II: SB TEST MIXES**

<i>Sample #</i>	
SB-1	3.5% bentonite slurry 25% fines 10% gravel
SB-2	5% bentonite slurry 25% fines 10% gravel
SB-3	6.5% bentonite slurry 25% fines 10% gravel
Control	0% bentonite 0% fines addition to native soil

Notes:

1. The specified fines and gravel will consist of naturally occurring and supplemental materials (as required).
2. The balance of the samples composition will be native soils and tap water such that the mixtures achieve a required slump between 4 and 6 inches.
3. The percentages to be evaluated are based upon experience and review of the scientific literature. Should the testing of any phase of the program indicate that other mixture percentages need to be evaluated, they will be undertaken.



# LEGEND

\* EVENT/SUBMITTAL

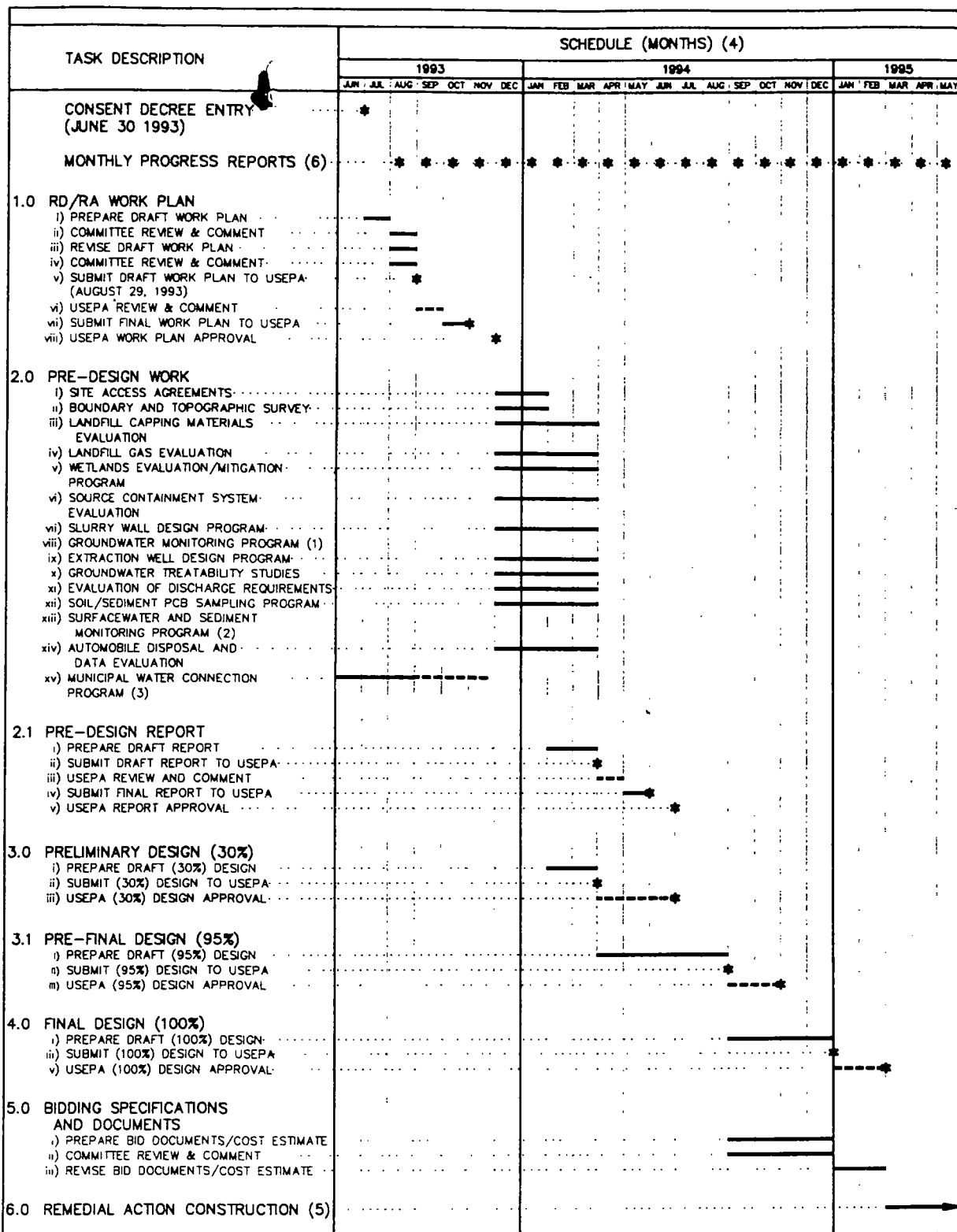
— ACTIVITY DURATION (DAYS)

NOTE: THE SCHEDULE WILL BE NECESSARILY MODIFIED  
DEPENDENT UPON U.S. EPA REVIEW AND  
APPROVAL PERIODS.

1) ACTIVITY DURATION UNKNOWN, DEPENDENT  
UPON LOCAL GOVERNMENT APPROVAL/SCHEDULE

figure 9.1  
PROJECT RD SCHEDULE  
ACTIVITIES KEYED TO LODGING OF CD  
G & H LANDFILL SITE  
*Macomb County, Michigan*

CRA



**NOTES:**

- (1) GROUNDWATER MONITORING PROGRAM TO BE IMPLEMENTED WITHIN 6 MONTHS OF CONSENT DECREE LODGING AND SEMI-ANNUAL THEREAFTER (MARCH/SEPTEMBER 1993/94/95) (SEE FIGURE 8.1)
- (2) SURFACEWATER AND SEDIMENT MONITORING PROGRAM TO BE IMPLEMENTED ANNUALLY AFTER CONSENT DECREE LODGING (SEPTEMBER 1993/94/95)
- (3) TO BE COMPLETED WITHIN 12 MONTHS OF LODGING, DEPENDENT UPON LOCAL GOVERNMENT APPROVAL/SCHEDULE
- (4) THE SCHEDULE WILL BE NECESSARILY MODIFIED DEPENDANT UPON USEPA REVIEW AND APPROVAL PERIODS
- (5) TO BE DEFINED IN FINAL DESIGN SUBMITTAL
- (6) MONTHLY PROGRESS REPORTS DUE 10TH BUSINESS DAY OF EACH MONTH

\* EVENT  
 — ACTIVITY DURATION  
 --- ACTIVITY OF UNDETERMINED DURATION

figure 9.2  
 PROJECT RD/RA SCHEDULE  
 ACTIVITIES KEYED TO ENTRY OF CD  
 G & H LANDFILL SITE  
 Macomb County, Michigan

**CRA**

Drill rigs and associated drilling equipment will be thoroughly cleaned by a high-pressure, steam-cleaner wash to remove soils and other foreign matter prior to demobilization from the Site.

#### A.3.1.2      Sampling Equipment

All sampling equipment which may come in contact with potentially contaminated materials shall be decontaminated prior to field use and after each sample is collected to prevent cross-contamination of the samples. Duplicate samples shall be collected concurrently with original samples, therefore, sampling equipment will not be decontaminated before collection of the duplicate. Decontamination of equipment will be performed as follows:

- i)      clean water and non-phosphate detergent wash using a brush, if necessary, to remove all visible foreign matter;
- ii)     rinse thoroughly with potable water;
- iii)    rinse with methanol;
- iv)    rinse thoroughly with deionized water;
- v)     allow the equipment to air dry on a clean plastic sheet as long as possible: and
- vi)    wrap in aluminum foil or polyethylene sheeting until required and during transport to the sampling Site.

CRA RESPONSES TO U.S. EPA  
COMMENTS ON THE DRAFT  
RD/RA WORK PLAN  
FOR THE  
G&H LANDFILL SITE  
MACOMB COUNTY, MICHIGAN

**U.S. EPA Comment No. 1**

*Page 6: Proposed modifications to the scope of the RD/RA Work Plan will (not may) be presented to USEPA for review/approval.*

**CRA Response**

Agreed. The text on Page 6 has been revised accordingly.

**U.S. EPA Comment No. 2**

*Page 23: Any new capping alternatives will have to comply with the substantive requirements of Michigan Act 64 unless the Consent Decree/SOW is modified. However, the Group should not be discouraged from evaluating viable capping options because of this.*

**CRA Response**

Other viable capping options meeting the equivalent performance of Michigan Act 64 will be evaluated during the pre-design landfill capping materials evaluation (see Section 4.3 of the RD/RA Work Plan). The landfill capping materials evaluation will be presented in the Pre-Design Report which will be submitted with the 30% Design Report.

**U.S. EPA Comment No. 3**

*Page 47: An appropriate size hammer should be used with a 3-inch split spoon for the collection of soil samples, as the 140 pound hammer is used with a 2-inch split spoon.*

**CRA Response**

Standard penetration results (i.e. number of hammer drops required to drive the split spoon through 6-inch increments) are not required in the SWDP. Split spoons will be used to collect soil samples only. Therefore, the reference associated with recording the number of hammer drops during split spoon sampling has been deleted. Geotechnical information will be obtained from the existing boreholes completed during the RI (as required). There are existing boreholes in proximity to the slurry wall alignment.

**U.S. EPA Comment No. 4**

*Page 52: A low flat rate should be maintained to minimize the loss of VOCs while filling the sample drum with groundwater.*

**CRA Response**

The text has been revised to ensure minimal loss of VOCs during sample collection.

**U.S. EPA Comment No. 5**

*Pages 46, 48, 49: The following are recommendations made concerning the procedures listed on these pages:*

**U.S. EPA Comment No. 5a.**

*Sampling of boreholes should be made at least at 5-foot intervals, rather than at up to 10 feet, and at a minimum of 10 feet into the lacustrine till layer.*

**CRA Response**

The text has been revised to indicate that the sampling of boreholes will be made at 5-foot intervals and will be advanced a minimum of 10 feet into the lacustrine till layer.

**U.S. EPA Comment No. 5b.**

*Samples should be photographed to provide a geologic record of the boreholes.*

**CRA Response**

Page 48, second paragraph, indicates that the samples will be photographed (as required).

**U.S. EPA Comment No. 5c.**

*Methanol should be used as a solvent rinse when cleaning the split spoon, for acetone contamination can result from using isopropanol.*

**CRA Response**

The cleaning protocol for the split spoon samplers has been revised accordingly.